

RESEARCH REPORT



**COFFEE BOOM, GOVERNMENT
EXPENDITURE, AND
AGRICULTURAL PRICES:
THE COLOMBIAN EXPERIENCE**

**Jorge García García
Gabriel Montes Llamas**

August 1988

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FOREWORD

In this report Jorge García García and Gabriel Montes Llamas examine the effects on agricultural incentives in Colombia of two influential economic forces: the coffee boom in the 1970s and rapidly expanding public sectors. In Colombia, the turbulence in trade and exchange rate regimes brought about by the coffee boom presents a classic example of the Dutch-disease phenomenon. This report is part of an extensive body of IFPRI work on these forces, which includes an earlier study by García, *The Effects of Exchange Rates and Commercial Policy on Agricultural Incentives in Colombia: 1953-78*, Research Report 24, and others including *Agriculture and Economic Growth in an Open Economy: The Case of Argentina*, Research Report 36; *The Effects of Trade and Exchange Rate Policies on Agriculture in Nigeria*, Research Report 55; *The Effects of Trade and Exchange Rate Policies on Agriculture in Zaire*, Research Report 56; and *Production Incentives in Philippine Agriculture: Effects of Trade and Exchange Rate Policies*, Research Report 59.

In their analysis of government's expanding role as a demander of goods and services, García and Montes also examine the effects on farm output and on rural employment as they pertain to rural incomes and wage rates under the argument that government expenditure biased toward the nontraded sector discourages growth in agriculture and industry. Two earlier reports, *Government Expenditures on Agriculture in Latin America*, Research Report 23, and *Government Expenditures on Agriculture and Agricultural Growth in Latin America*, Research Report 50, relate to this work.

John W. Mellor

Washington, D. C.
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SUMMARY

This report analyzes the effects of variations in the external terms of trade and in government expenditure on relative product prices, real agricultural wages, and the distribution of income between labor and nonlabor factors of production in Colombia during the period 1967-83. The Dutch disease phenomenon in Colombia resulting from the effects of changes in terms of trade has been widely analyzed in the literature. This report builds on this body of work by looking at various categories of traded goods, with emphasis on the effects on agricultural commodities. Moreover, the role of the government as a demander of commodities in the economy is incorporated and its effect on relative agricultural prices is analyzed. In addition to the direct effects of terms-of-trade changes, the report measures the impact on factorial income distribution in the traded and nontraded sectors and on real agricultural wages.

Agriculture, the most important sector of the Colombian economy, generates about 25 percent of GNP, produces about 65 percent of the domestic food supply, and earns about 65 percent of Colombia's legal foreign exchange revenues. Coffee, the main agricultural export, accounts for about half of these earnings. During 1967-74 a combination of favorable world economic conditions and moderate fiscal and monetary policies stimulated overall growth and a stable economic environment. In the mid-1970s, however, a sharp rise in the export price of coffee led to an increase in coffee production and subsequently an increase in the quantity exported.

As a result of these economic developments, the price of nontraded goods increased relative to the price of noncoffee tradables, thereby discouraging production in the tradable parts of the agricultural and manufacturing sectors. The report analyzes empirically the factors that explain the change in relative prices between noncoffee tradable and nontraded activities in general and between broad aggregates of agriculture and the nontraded goods sectors of the rest of the economy, in particular.

Changes in product prices affect factor prices and the functional distribution of income across sectors. Using a simple framework, the effect of changes in coffee prices on the income of the nonlabor factors of production is estimated, and it is found that an increase in the price of coffee tends to reduce nonlabor income and to increase labor income.

Agricultural wages are the lowest in the country. Therefore it is not possible to study the determinants of poverty in agriculture without also addressing the existence and permanence of low real wages. Wages in the cities tend to be higher, and people migrate to the urban sector with the expectation of finding a job with higher pay. The higher the rate of urban unemployment, the lower the expected urban real wage. On the other hand, the real wage that farmers will pay depends on the price of farm output and the productivity of labor. The rural wage rate is therefore affected by the rate of urban unemployment, real wages in both rural and urban areas, the size of the rural population, the productivity of labor in agriculture, and the price of agricultural products.

The empirical analysis of the determinants of real wages in agriculture finds that the size of the capital stock, higher prices of agricultural products, and a higher urban wage tend to increase real wages in agriculture, while high rates of urban unemployment and a larger population in agriculture tend to reduce them. Therefore, macroeconomic

policies that depress agricultural prices work against rural laborers by reducing their real wages.

Another issue is agricultural supply response, which is estimated for the most representative products of Colombian agriculture—rice, cotton, wheat, coffee, and livestock—to determine whether changes in relative prices introduced by movements in coffee prices or in the government's expenditure policy have any effect on output. The results show that output responds to changes in prices. These findings point up the importance of price incentives in agricultural production and highlight the crucial effects of macroeconomic developments and policies in determining incentives for agriculture.

The report elaborates a consistent set of accounts for agriculture, which can help clearly establish the role of agriculture in the Colombian economy. A series of prices of traded and nontraded goods for the agricultural and nonagricultural sectors are generated, making it possible to analyze the effects of changes in coffee prices and government expenditure on relative prices among broad categories of products. Time series of total income for labor and nonlabor factors of production are constructed for noncoffee tradables, nontradables, and coffee.

Finally, the report discusses pros and cons of various policies that might alleviate eventual adverse effects on other sectors of a boom in one sector, including reducing government spending, taxing gains in the booming sector, encouraging exporters to leave gains outside the country until the boom ends, and placing a tariff on coffee, the proceeds from which would be used to subsidize other agricultural exports.

The finding that agricultural output does respond to price changes is important because it explains the decline in Colombian agriculture, which has often been blamed on the competition of imports. It also implies that spurring the economy by increasing government expenditure may not be the answer to agricultural growth because it may only serve to reduce relative agricultural prices.

INTRODUCTION

When a large sector of an economy expands rapidly, such as coffee during a boom period in Colombia, it draws resources away from other sectors, with consequent repercussions in relative prices, wages, distribution of income, and terms of trade. This phenomenon, called the "Dutch disease," has been analyzed for Colombia by a number of authors.¹ This report extends their analysis, examining in greater detail the effects on the various categories of traded goods, especially on agricultural commodities.

Because more than 50 percent of Colombia's legal foreign exchange earnings is derived from coffee,² changes in the world price of coffee profoundly affect the Colombian economy, including foreign exchange revenues, real income, and expenditures. Changes in external coffee prices also bring about changes in domestic relative prices. Changes in government policies on taxation and expenditure also alter relative prices.

Between 1967 and 1974, Colombia reduced its import substitution bias and experienced growth rates in GNP of 6.4 percent annually. Since 1975, however, economic activity has decelerated.

Two important actors in the economic development of Colombia in the second half of the 1970s were, first, the coffee boom, which started in 1975, and, with some interruption, lasted until 1980; and second, the growth of government spending and the resulting fiscal deficit, which led to the sharp deterioration of the international reserve position of the country. A third important actor was the drug boom, essentially of marijuana and cocaine. According to estimates by Hernando J. Gomez, during the period 1981-85 net income from drug traffic ranged from a low of 2.6 percent of GDP in 1985 to a high of 6.4 percent of GDP in 1982.³

¹ Sebastian Edwards, "Coffee, Money, and Inflation in Colombia," *World Development* 12 (November/December 1984): 1107-1117; Sebastian Edwards, "Commodity, Export Prices and the Real Exchange Rate in Developing Countries," in *Economic Adjustment and Exchange Rate in Developing Countries*, ed. Sebastian Edwards and Liaquat Ahamed (Chicago: University of Chicago Press, 1986), pp. 235-260; Sebastian Edwards, "A Commodity Export Boom and The Real Exchange Rate: The Money-Inflation Link," in *Natural Resources and the Macroeconomy*, ed. J. Peter Neary and Sweder van Wijnbergen (Cambridge, Mass.: MIT Press, 1986), pp. 229-251; Linda Kamas, "Dutch Disease Economics and the Colombian Export Boom," *World Development* (September 1986): 1177-1198; and Carlos Diaz-Alejandro, "Latin American Debt: I Don't Think We Are in Kansas Anymore," *Brookings Papers on Economic Activity* (1984): 2.

For analysis incorporating the agricultural sector, see Jorge García García, "Aspects of Agricultural Development in Colombia: 1970-1982," paper prepared for the Colombia Division of World Bank, Bogotá, April 1983 (mimeographed); Gabriel Montes, "Políticas Macroeconómicas y Desarrollo Agropecuario," *Revista Nacional de Agricultura* (December 1984): 125-149; and Vinod Thomas et al., *Linking Macroeconomic and Agricultural Policies for Adjustment and Growth* (Baltimore: Johns Hopkins University Press, 1985), especially chapters 1-4.

² This figure refers to foreign exchange earnings from legal exports. Exactly how much foreign exchange is earned from illegal activities (cocaine and marijuana) and how much is brought back to Colombia through the Central Bank is not known. For estimates of the size of illegal activities and their contribution to foreign exchange revenues of the Central Bank, see Roberto Junguito and Carlos Caballero, "La Otra Economía," *Coyuntura Económica* 8 (1978): 101-141; and Hernando J. Gomez, "The Colombian Illegal Economy: Size, Evolution, Characteristics and Economic Impact," in *State and Society in Contemporary Colombia: Beyond The National Front*, ed. Bruce Bagley, Francisco Thoumi, and Juan Tokatlian (Boulder, Col.: Westview Press, 1988).

³ See Gomez, "Colombian Illegal Economy," Table 7.

This report commits a sin of omission by leaving drugs out of the analysis. Unfortunately, the information required to incorporate it did not exist when this study was done. Even Gomez's study, which became available after a preliminary version was finished, does not cover the entire period analyzed in this report. With the drug sector left out, the impact of the coffee boom and the expansion of government expenditure may be overestimated. However, the extent of overestimation is reduced as long as the main effect of the drug boom is felt on expenditures and only a small amount of the foreign exchange earned abroad is brought into the country. In 1982, for example, when the estimated effect of the drug activity was largest—US\$2.5 billion—the sale of dollars to the Central Bank from illegal activities is estimated to have been US\$23 million, whereas in 1979 those sales were estimated at US\$312 million, equivalent to 20 percent of the total increase in international reserves in that year.⁴

Substantial increases in the external price of coffee and later in the volume of coffee exports characterized the coffee boom. The rise in coffee prices increased the real income of most Colombians, but particularly those in the coffee sector. As a result, spending on nontraded commodities (goods produced for domestic consumption only) and on export and import-competing goods (traded commodities) increased. The higher coffee prices and larger volume of coffee exports led to a substantial accumulation of international reserves, an increase in the rate of monetary expansion, and an acceleration of inflation. The induced rise in expenditure increased the demand for all commodities (nontraded and traded), and as a result the price of nontraded commodities relative to the price of traded ones went up. Thus, the incentives to produce noncoffee exports and import-competing commodities declined, and production in the noncoffee tradable sector was discouraged.

The effects of increases in government expenditure on relative prices are not as clear as those from an increase in the coffee price because such expenditures tend to affect both nontraded and noncoffee tradable commodities. When the marginal propensity of the government to spend on nontraded goods is higher than that of the private sector, a rise in government expenditure increases the price of nontraded goods. This seems to have been the case in Colombia, where an increase in the ratio of government expenditure to the GDP caused the relative price of nontraded commodities to rise.

Turning from the effects on agricultural prices to the determinants of real wages, empirical analysis finds that a growing capital stock, higher prices of agricultural products, and a higher urban wage all tend to increase real wages in agriculture, while high rates of urban unemployment and a larger population in agriculture tend to reduce it.

Another point addressed in this report is the issue of agricultural supply response. To understand and measure properly the supply response of agricultural output, it is necessary to model the interactions between factor and product markets in a dynamic framework. Because of its complexity and data requirements, this exercise is beyond the scope of the present report. Simpler methods to analyze the supply response of agriculture are used here.

Supply response is estimated for the most representative products of Colombian agriculture (rice, cotton, wheat, coffee, and livestock). The purpose of estimating supply response is to determine whether changes in relative prices introduced by movements in coffee prices or in the government's expenditure policy have any effect on output.

One important contribution of this report is the elaboration of a consistent set of accounts for agriculture, which can help establish clearly its role in the Colombian

⁴ Ibid., Tables 7 and 17.

economy. Another is the generation of a series of prices of traded and nontraded goods for the agricultural and nonagricultural sectors, making it possible to analyze the effects of changes in coffee prices and government expenditure on relative prices among broad categories of products. Finally, a time series of total income for labor and nonlabor factors of production is constructed for noncoffee tradables, nontradables and coffee, without which the analysis of the redistribution of income as the result of the coffee boom would not be possible.

THE ROLE OF AGRICULTURE IN THE COLOMBIAN ECONOMY AND MAIN ECONOMIC DEVELOPMENTS, 1967-83

Agriculture is the single most important sector of the Colombian economy. It generated 30 percent of the country's real gross national product (GNP) in the late 1960s and about 25 percent in the second half of the 1970s and early 1980s (see Table 1 and Figure 1).⁵ The gross value of agricultural output is roughly divided between coffee (32 percent), livestock (33 percent), and other agricultural production (35 percent). Agriculture is the main source of food for the Colombian population. The gross value of food output during the period is 66 percent of gross agricultural output (see Table 1). The real gross value of food output is 2 percent higher than the net supply of food, but since 1979 that positive gap has declined. On the other hand, between 1967 and 1983 physical food output increased by 3.8 percent per year, while total apparent food consumption increased by 3.6 percent. Food output is highly diversified and stable.⁶ Thus, the diversity of Colombian agriculture contributes enormously to the stability of food supply in the country.

When measured by the import-output and export-output ratios, external trade is not important for agriculture; however, most Colombian agriculture can be classified as tradable (Table 1).⁷ In fact, for agriculture as a whole, agricultural output classified as exportable represents an average of 61 percent of the gross value of agricultural output, and importables represent 13 percent. This points up the close link between external events and developments in domestic agriculture. For noncoffee agriculture, the combined output of exportables and importables is, on average, 44 percent of its real gross value, out of which 32 percentage points could be categorized as exportables. Food output classified as tradable represents 41 percent and nontradables 26 percent of total agricultural output. Out of the 41 percent in the tradable category, 29 percentage points are exportables.

Agriculture was the main source of registered foreign exchange earnings for Colombia during the period. Agricultural exports were 67 percent of real exports of goods in 1970 and 65 percent in 1983, and close to 56 and 55 percent of real exports of goods and services in the same years. The average contribution of the sector to commod-

⁵ According to the definition used by DANE, agriculture is composed of three sectors: production of unprocessed "pergamino" coffee, other agricultural production, and animal production. With this grouping the agricultural sector (*sector agropecuario*) represents 22 percent of GDP. The broader definition of agriculture used in this report includes coffee processing and sugar manufacturing as part of agriculture. See Colombia, Departamento Administrativo Nacional de Estadística, División de Cuentas Nacionales, *Metodología de las Cuentas Nacionales de Colombia-Según el Nuevo SCN (Versión Preliminar)*, January 1979 (mimeographed). For a discussion of the definition of agriculture used in this report and the way the series for the agricultural sector was derived, see Appendix 1.

⁶ Jorge García García, "Es Importante la Seguridad en el Suministro de Alimentos en Colombia," *Revista de Planeación y Desarrollo* (September-December 1979); and Jorge García García and Lía Guterman, "The Contribution of Food Aid to Food Security in Colombia," a paper prepared for the Food and Agriculture Organization of the United Nations, Bogotá, 1984 (mimeographed).

⁷ For a definition of exportables, importables, and nontraded sectors of agriculture, see Appendix 1.

Table 1—Main indicators of the role and structure of agriculture in the Colombian economy, selected years, 1967-83

Indicator	1967	1971	1975	1979	1983
Real value added in agriculture as a share of GDP			(percent)		
Agriculture (01-03)	25.8	23.4	23.0	22.2	21.7
Processed coffee (08)	3.7	3.2	3.2	3.4	2.8
Sugar (12)	0.3	0.5	0.6	0.5	0.6
Broad agriculture (01-03,08,12)	29.9	27.0	26.8	26.2	25.1
Structure of real gross output					
Pergamino coffee (01)	11.1	9.2	8.5	10.4	11.8
Other agricultural production (02)	34.1	33.9	35.0	33.4	32.2
Animal production (03)	31.7	34.6	33.6	31.3	33.4
Processed coffee (08)	20.2	18.8	18.7	21.2	18.3
Sugar (12)	2.9	3.6	4.1	3.7	4.4
Total agriculture (01-03,08,12)	100.0	100.0	100.0	100.0	100.0
Noncoffee (02,03,12)	68.7	72.0	72.7	68.4	70.0
Coffee (01,08)	31.3	28.0	27.3	31.6	30.0
Tradable goods	n.a.	74.4	74.1	73.4	73.8
Exportable	n.a.	60.7	61.1	61.1	59.8
Importable	n.a.	13.7	12.9	12.3	14.0
Nontraded goods	n.a.	25.6	25.9	26.6	26.2
Food	n.a.	65.7	66.2	63.3	65.5
Tradable	n.a.	41.7	42.0	38.2	40.7
Exportable	n.a.	28.7	29.8	26.5	27.4
Importable	n.a.	13.0	12.2	11.7	13.3
Nontraded	n.a.	24.0	24.1	25.1	24.8
Nonfood	n.a.	34.3	33.8	36.7	34.5
Tradable	n.a.	32.6	32.0	35.2	33.2
Exportable	n.a.	32.0	31.3	34.6	32.4
Importable	n.a.	0.7	0.7	0.6	0.7
Nontraded	n.a.	1.7	1.8	1.5	1.4

Sources: Derived from Colombia, Departamento Administrativo Nacional de Estadística (DANE), *Cuentas Nacionales de Colombia 1970-1983* (Bogotá: DANE, 1984); and unpublished data from DANE, Division de Cuentas Nacionales.

Notes: The numbers in parentheses are the sector numbers assigned in the national accounts. n.a. means not available. Pergamino is unwashed coffee.

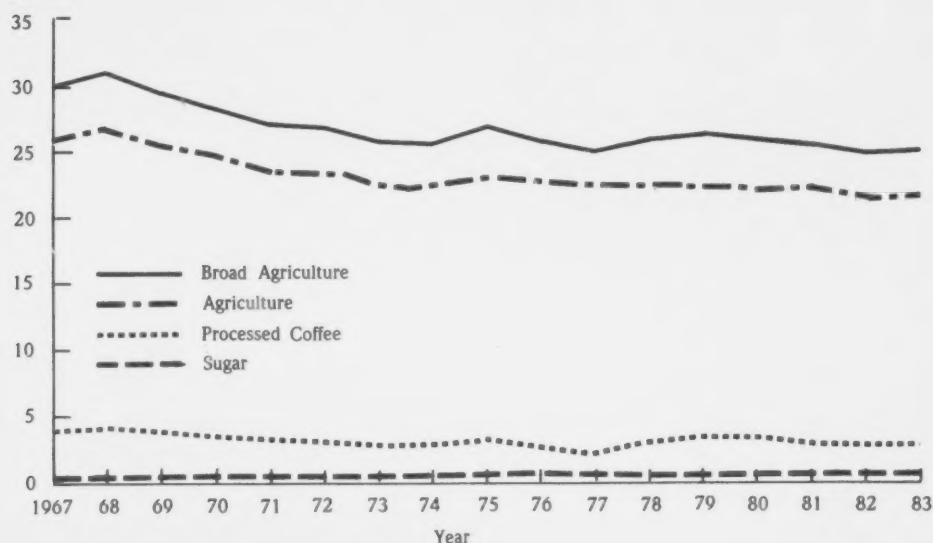
ity exports and exports of goods and services during the period 1970-83 was 61 and 51 percent, respectively.

Coffee was the principal export product, contributing an average of 44 percent of total real commodity exports during the period 1970-83. Noncoffee agricultural exports, in turn, amounted to an average of 17 percent of total commodity exports, and the average share of exports of agricultural food products in total commodity exports was about 12 percent. Imports of agricultural commodities were relatively small during the period, an average of 5 percent of total imports of goods and services and close to 6 percent of commodity imports. Imports of food products were, on average, 5.3 percent of total commodity imports and around 5.7 percent of total commodity exports. Thus, the country is a net exporter of agricultural commodities in general (with and without coffee) as well as of agricultural food products (see Table 2). The small share of food imports in total imports means that the burden of the food import bill on foreign exchange earnings is small enough to discard any threat to the balance of payments arising from sudden increases in the volume of imports or in their external price.

For agricultural food products, the trade balance was positive and low during each year of the 1970-83 period, reaching an average of 2 percent of the real gross value

Figure 1—Real value added in agriculture as a share of real GDP

Share of Real GDP
(percent)



Source: Derived from Colombia, Departamento Administrativo Nacional de Estadística, *Cuentas Nacionales de Colombia 1970-1983* (Bogotá: DANE, 1984).

Notes: For the purposes of this report, agriculture includes unwashed (*Pergamino*) coffee, livestock, and other agricultural products, with the exception of processed coffee and sugar, which are included in "broad agriculture."

Table 2—Share of agricultural imports and exports in total imports and exports, selected years, 1970-83

Imports/Exports	1970	1974	1978	1982	1970-83 Average
	(percent)				
Share of real imports					
Agriculture/total commodities	6.17	6.88	7.35	6.69	6.52
Food/total commodities	5.68	6.41	6.79	6.01	5.94
Agriculture/goods and services	5.36	5.90	6.56	6.14	5.76
Food/goods and services	4.93	5.50	6.06	5.51	5.24
Share of real exports					
Agriculture/total commodities	67.02	59.25	62.30	64.41	61.12
Coffee/total commodities	47.34	43.54	44.39	46.50	44.10
Food/total commodities	11.08	10.09	12.29	13.27	11.10
Agriculture/goods and services	55.83	48.44	52.00	53.97	51.21
Coffee/goods and services	39.43	35.60	37.05	38.97	36.97
Food/goods and services	9.23	8.25	10.26	11.12	9.29

Sources: Derived from Colombia, Departamento Administrativo Nacional de Estadística (DANE), *Cuentas Nacionales de Colombia 1970-1983* (Bogotá: DANE, 1984); and DANE, Division de Cuentas Nacionales, "Working Sheets: 1970-83," Bogotá, 1984.

of output. However, the trade balance is not positive for each agricultural product. For example, the trade balance in cereals and production of animals other than cattle was negative throughout the period and negative in recent years for vegetables and legumes (see Table 3).

External Trade

During the period 1967-83, total commodity imports increased at an annual rate of 7.2 percent and exports at 4.3 percent. The annual rate of growth of real agricultural imports was 5.0 percent and that of agricultural exports was 4.0 percent. However, when only the period 1975-83 is considered, the annual rate of growth of total commodity imports jumps to 9.9 percent and agricultural imports to 10.6 percent. The growth rate for agricultural imports accelerated to 12.7 percent per year in the final years, 1979-83. Total and agricultural exports, on the other hand, grew at 2.9 and 4.4 percent between 1975 and 1983 because of coffee, but noncoffee agricultural exports declined at the rate of 1.3 percent per year. Despite the relatively high rates of growth of imports, agricultural imports remained low relative to total imports (7.0 percent) and real agricultural value added (4.0 percent), thus casting serious doubts on popular beliefs about the potentially negative effects that the increase in the volume of agricultural imports had on the growth and development of agriculture and on the country's balance-of-payments position during the period.

External trade is not a high proportion of GNP. In fact, during the period 1965-74 the ratio fluctuated between 17 and 13 percent for total exports and between 21 and 12 percent for total imports. The low value of this ratio is also a strong characteristic of the noncoffee agricultural sector. Thus, between 1970 and 1983, on average, its export-gross output ratio was almost 9 percent and its import-gross output ratio was 4 percent. Therefore, strong changes in the volume of trade probably have only a small effect on the short-term economic performance of noncoffee agriculture as a whole. However, for specific products such as sugar or cotton—where the volume of trade is high relative to the volume of output (40 percent or more)—changes in export volume will have a significant effect on their performance.

External trade is a small proportion of agricultural food production. During the period 1970-83, imports of agricultural food products were, on average, 4.1 percent of real gross output; their largest value was 5.6 percent in 1971. Likewise, real exports of food products averaged 6.1 percent of gross output between 1970 and 1983.

In contrast with agriculture, the industrial sector is a net importer, with a negative trade balance equivalent to 18 percent of the sector's real gross value of output during 1970-83. Moreover, while agriculture generated more than 60 percent of commodity exports, industry only generated 33 percent. On the other hand, imports of agricultural commodities were only 6.4 percent of total commodity imports, while those of industrial goods were 91.4 percent.

In summary, agriculture is the main source of foreign currency earnings for Colombia and as such provides the necessary foreign exchange for the imports of all sectors. Because the country is a net exporter of agricultural commodities, policies that discriminate against exports or reduce the relative price of exportables have a negative effect on agriculture. This effect is negative because 75 percent of total agricultural output is tradable, of which 63 percent is in the exportable category.

Although the increase in imports of agricultural commodities is considered to be the main cause of the stagnation of agriculture in the 1970s and early 1980s, the

Table 3—Real agricultural exports and imports relative to the real gross value of output in agriculture, selected years, 1970-83

Sector	1970	1974	1978	1982	1983
	(percent)				
Exports (f.o.b.)					
Other agricultural production (02)	11.1	8.7	10.3	9.3	9.2
Animal production (03)	4.7	2.8	5.8	2.7	2.1
Processed coffee (08)	87.1	87.0	89.4	88.3	88.1
Sugar (12)	41.5	37.5	38.4	47.9	45.8
Total agriculture (01,02,03,08,12)	23.2	20.6	23.8	22.0	21.8
Noncoffee (02,03,12)	9.6	7.4	9.6	8.6	8.1
Coffee (01,08)	56.6	57.2	58.8	54.8	53.6
Food	6.0	5.2	7.2	6.8	6.2
Nonfood	54.1	51.5	55.5	52.4	51.3
Imports (c.i.f.)					
Other agricultural production (02)	6.1	7.6	7.5	11.4	11.1
Animal production (03)	1.4	0.5	0.4	0.5	0.4
Noncoffee agriculture (02,03,12)	3.6	3.9	4.8	5.5	5.3
Food	3.7	4.0	4.8	5.3	5.2
Nonfood	0.6	0.6	0.8	1.2	0.9
Real agricultural trade balance relative to real gross value of output					
Other agricultural production	5.0	1.1	2.8	-2.1	-1.9
Cereals (2.1)	-18.1	-22.3	-25.0	-27.9	-26.7
Sugarcane (2.2)	0.3	1.6	0.2	0.2	0.3
Raw tobacco (2.3)	74.9	72.4	68.6	44.4	30.1
Tubers (2.4)	-0.1	0.2	0.4	0.8	0.5
Vegetables and legumes (2.5)	-1.5	3.0	0.8	-24.4	-33.3
Fruits (2.6)	27.3	27.1	37.3	34.6	32.5
Oil products (2.7)	-1.6	-10.3	1.8	-13.0	-19.4
Fibers (2.8)	57.4	26.9	42.3	24.2	24.2
Other agricultural products (2.9)	-12.7	2.2	12.9	15.1	19.1
Animal production (03)	3.3	2.3	5.4	2.3	1.7
Cattle (3.1)	6.8	4.0	9.0	4.2	3.2
Poultry (3.2)	-0.6	-0.3	-0.3	-0.2	-0.2
Other animal products (3.4)	-14.7	-5.2	-2.7	-4.1	-3.4
Processed coffee (08)	87.1	87.0	89.4	88.3	88.1
Sugar (12)	41.5	37.5	20.3	47.9	45.8
Agriculture (01,02,03)	3.6	1.5	3.5	0.1	-0.1
Broad agriculture (01-03,08,12)	20.6	17.7	20.4	18.1	18.1
Noncoffee agriculture	5.9	3.5	4.8	3.1	2.8
Coffee agriculture	56.6	57.2	58.8	54.8	53.6

Sources: Derived from Colombia, Departamento Administrativo Nacional de Estadística (DANE), *Cuentas Nacionales de Colombia 1970-1983* (Bogotá: DANE, 1984); and DANE, Division de Cuentas Nacionales, "Working Sheets: 1970-83," Bogotá, 1984.

partial evidence here does not support this argument. The causes of stagnation seem to arise from domestic macroeconomic policies and external events rather than from import competition, as will be shown subsequently.

Main Economic Developments, 1967-83

Growth of Output and Evolution of Expenditure

Colombia maintained a relatively high rate of growth between 1965 and 1978, 5.5 percent per year, but economic activity has decelerated substantially since 1979. GDP grew only 2.1 percent annually in the period 1979-84. Agriculture, on the other hand, grew by 3.9 percent a year during 1965-78 but 1.3 percent during 1979-84. In 1967

an important effort to rationalize economic policy was undertaken, which, combined with a favorable environment in the world economy, made it possible to reach an average annual growth rate of 6.4 percent between 1967 and 1974, while agriculture grew at 3.7 percent. Growth continued at 4.7 percent a year in 1974-78, influenced primarily by the boom in prices and exports of coffee. As the result of domestic policies and world economic recession, growth has decelerated since 1979. Between that year and 1981 the growth rate of GDP averaged 3.7 percent per year, but it fell to 0.9 percent in 1982 and to 1.6 percent in 1983.⁸

Between 1967 and 1974 the rate of growth was sustained mainly by agriculture, manufacturing, and commerce, which grew at 4.3, 8.6, and 8.3 percent per year, respectively. Agriculture and manufacturing grew in response to export incentives and the expansion in world and domestic demand. Although the rate of agricultural growth remained at 4.5 percent between 1974 and 1978, mainly as the result of increased coffee production and exports, the rate of growth of manufacturing declined to 5.2 percent, while the services sector experienced the highest growth rate, 7.4 percent per year. Since 1978, the deceleration in the rate of growth has spread to all sectors, but mainly to manufacturing, which fell to 1.0 percent per year between 1978 and 1983.

Population and Employment

By 1985, Colombia had a total population of about 28.5 million. The annual rate of population growth has fallen in the last 30 years, from 3.4 percent in the 1950s to 2.5 percent between the mid-1960s and 1970s, and to an even lower 1.9 percent between 1975 and 1985. Another development is the increasing share of urban population in total population as a result of rural-urban migration. The urban population grew by about 4.1 percent per year between 1951 and 1985, compared with 2.6 percent per year for the total population, and the share of urbanites in the total population increased from 38.5 percent in 1951 to 65.4 percent in 1983.⁹

Between the mid-1950s and the early 1970s the growth in labor supply surpassed the increase in labor demand, and conditions in the labor market deteriorated. However, between 1974 and 1979, despite a substantial growth of the economically active population (3.4 percent per year), unemployment rates declined due to a phenomenal growth in employment. The urban unemployment rate in seven major cities dropped from 12.7 percent in June 1974 to 8.9 percent in September 1979. The largest share of the surge in employment between 1974 and 1979 went to the service and construction sectors—about 43 percent of the total—while manufacturing gained 22 percent and agriculture 16 percent.¹⁰

These changes in population affected real wages and real wage differentials between the urban and rural sectors. In the 1950s, the large rate of increase in population and discrimination against the agricultural sector caused real wages in agriculture to stagnate, while those in the industrial sector increased. As a result, in 1960 real agricultural wages were only 48 percent of blue-collar wages in manufacturing, while in 1951 they had been 70 percent. In the 1960s real wages in agriculture grew by 1.8 percent per

⁸ Data for computing rates of growth of GDP are from Colombia, Banco de la República, *Cuentas Nacionales de Colombia, 1950-1967 and 1968-1971*, and from Colombia, Departamento Administrativo Nacional de Estadística, *Cuentas Nacionales de Colombia, 1970-1984*, various issues (Bogotá: DANE: various years).

⁹ See World Bank, *Colombia: Economic Development and Policy Under Changing Conditions* (Washington, D.C.: World Bank, 1984), Table II.3.

¹⁰ *Ibid.*, Table II.9; and Colombia, Departamento Administrativo Nacional de Estadística, *Colombia Estadística 1985* (Bogotá: DANE, 1985), Table 5.1.

year, the differences between agricultural and manufacturing wages widened, and by 1970 real wages in agriculture were only 44 percent of wages in manufacturing. In the 1970s agricultural wages rose as a result of improvement in the terms of trade for agriculture, the substantial increase in urban employment, and the surge in illegal cash crops (marijuana). Large gains in productivity that began with the adoption of new technologies in several products (rice, coffee, and bananas, for example) also contributed. As a result, agricultural real wages grew by 3.9 percent per year. In 1977, at the height of the coffee boom, rural wages were about 69 percent of industrial wages, but as the rate of growth of rural wages declined, rural wages also fell in relation to urban wages, reaching 55 percent of industrial wages in 1982.¹¹

Trends in Commercial and Exchange Rate Policies

Commercial Policies

In looking at commercial and exchange rate policies during the postwar era in Colombia, two periods can be identified: 1950-66, when import substitution and fixed exchange rate policies were dominant, and 1967-82, when a more open-economy approach to commercial policy was implemented. The implementation of these two policies had important effects on the rate of growth of the different sectors, on employment, and on income distribution.¹²

During the first period industrial output grew rapidly, thereby increasing the sector's share of total GDP. The main instruments used in this industrialization effort were high tariffs and strong quantitative restrictions on imports of consumption goods, whereas imports of raw materials and capital goods were subsidized through low tariffs and an overvalued peso. As a result, industrial consumption goods had high rates of effective protection, while the rates of protection for agricultural commodities and industrial intermediate and capital goods were low and even negative.

A process of rationalization of economic policies began in 1967, and a gradual and moderate import liberalization policy was applied until 1982. During the period 1967-74 some measures to liberalize imports were introduced, and improvements in the administration of trade policy occurred. The reduction of quota restrictions between 1968 and 1973 was not accompanied by a simultaneous reduction in tariffs. Thus, the general level of nominal tariffs as well as the variance remained fairly constant between 1968 and 1973. In 1974 there was a large reduction of both, from an average of 45.5 percent in 1973 to 31.9 percent in 1974. The standard deviation and coefficient of variation also fell, from 36.8 to 21.7 and from 0.81 to 0.68, respectively. The reduction of tariffs continued during the second half of the 1970s, but at a much slower pace.

An important aspect of the rationalization process was the reduction of the antiexport bias of commercial policies. The agricultural sector and exportables in the industrial sector were particularly favored by the shift in policy, but in general all sectors did

¹¹ This information has been taken and processed from Colombia, Departamento Administrativo Nacional de Estadística, *Anuarios Generales de Estadística* (Bogotá: DANE, various years, 1950-77); Colombia, Departamento Nacional de Planeación, Unidad de Programación Global-División de Precios y Salarios, "Mercado Laboral en Colombia: 1950-1977," vol. 2, Bogotá, January 1980 (mimeographed); and Colombia, Departamento Administrativo Nacional de Estadística, *Boletín Mensual de Estadística*, various issues.

¹² For a fuller documentation of commercial and exchange rate policies in Colombia during the period 1967-82, see Jorge García García, "The Timing and Sequencing of Trade Liberalization: The Case of Colombia 1967-1982," paper prepared for the World Bank, Trade and Adjustment Division, Country Policy Department, Washington, D.C., January 1987 (mimeographed).

well in this period. The gradual movement toward import liberalization was intensified in 1979-81 and reversed drastically after 1982. Its evolution was largely influenced by movements in the external price of coffee and by the accompanying macroeconomic policies (exchange rate, fiscal, and monetary).

The sharp rise in the price of coffee in 1975 and the accumulation of international reserves were factors favoring further liberalization, but a revaluation of the peso as the result of this boom, coupled with a protectionist attitude in some spheres of the administration, halted that process in 1976. The government that took office in 1978 started to implement a large public works program, which led to the development of a substantial fiscal deficit, financed by external credit and money creation. Since the liberalization implemented during this period was essentially for stabilization purposes, its life was shortened by the unfavorable economic environment under which it was carried out. The revaluation of the peso and the application of a restrictive credit policy to offset the monetary effects of the expansive fiscal policy reduced the country's rate of economic growth, diminished private economic activity, discouraged nontraditional exports, and encouraged imports. By 1983, all measures taken to liberalize trade had been fully reversed.

Exchange Rate Policies

Before 1967, exchange rate policy was characterized by multiple rates fixed for long periods of time in the face of large inflationary pressures, thus producing unsustainable balance-of-payments deficits, leading to sporadic and large devaluations of the peso. In 1967, exchange rate policy was modified by the adoption of a crawling-peg system and reduction and eventual elimination of multiple exchange rates.

The rate of "crawl" varied over time according to changes in domestic and external circumstances, but it was influenced mainly by domestic and external rates of inflation, changes in the exchange rate of Colombia's main trading partners vis-à-vis the U.S. dollar, behavior of the country's terms of trade, and accumulation of international reserves.¹³ In 1968-73, when the exchange rates of the major world currencies and Colombia's terms of trade were stable, the rate of devaluation was essentially determined by the difference between the Colombian and U.S. rates of inflation.

In late 1974 and 1975 the crawl rate was accelerated in order to promote exports, to make up for a small decline in the real exchange rate during 1972 and 1973, and to compensate for the reduction in the rate of subsidization of minor exports, which was enacted in September 1974. In 1975 a coffee boom began, and in the following two years the rate of crawl declined. Although this reduced the monetary impact of the boom, it was not sufficient, and in May 1977 the peso was nominally revalued for the main export products plus all exports of services.¹⁴ The crawl rate was increased in 1978, but reduced in 1979, again to diminish the monetary effect of the accumulation of reserves generated by another coffee boom and heavy foreign borrowing by the government. After 1979 the crawl rate increased, and it was accelerated in 1981 and 1982 with the avowed purpose of improving the competitiveness of exports, which had declined sharply since 1975.

¹³ Edwards, "Commodity Export Prices and The Real Exchange Rate."

¹⁴ To nominally revalue the currency, a paper called a certificate of exchange was issued for each dollar surrendered to the Central Bank, with an initial maturity of 30 days and a discount of 10 percent if the exporter received pesos in exchange for dollars. Otherwise, the exporter would receive a certificate, which was freely negotiable on the stock exchange.

As a result of these influences, the real exchange rate increased between 1967 and 1971. It remained fairly stable until 1975, fell sharply in 1977 and 1978, and continued falling, although at a moderate rate, after 1980.

The evolution of the real effective exchange rate for minor exports, the relative price of exports and imports since 1967, and the profitability of exporting (the ratio of implicit prices received for sales in the domestic market versus sales in foreign markets) are presented in Table 4. From these figures it is clear that the real exchange rate and the profitability of exporting increased considerably from 1967 to 1974, but fell sharply afterward. Thus, the export promotion measures implemented after 1975 were not enough to compensate for the decline in the real exchange rate induced by the increase in the price and volume of coffee exports and the deleterious effect of larger government expenditure and deficit.

Balance of Payments and International Reserves

Colombia's external position improved from 1968 to 1975 because the deficit in the current account was more than compensated for by a moderate capital inflow that fluctuated between a net of US\$200 and \$400 million. As a result, international reserves went from US\$152 million in 1970 to US\$547 million in 1975 (see Table 5).

Between 1976 and 1980 the current account surplus generated by the gain in terms of trade was reinforced by positive capital flows, thereby leading to an accumulation of reserves that reached a peak of \$5.6 billion at the end of 1981. However, the external position of Colombia began to deteriorate in 1981 and took a sharp negative turn in 1982 when the current account deficit was \$2.9 billion and in 1983, when it was \$2.7 billion.

These balance-of-payments movements reflect several factors that were operating through the current and capital accounts. For the current account, developments in the world economy, the behavior of export incentives and import restrictions, and the evolution of coffee exports seem to have been the main determinants. As for the capital account, the level of domestic interest rates compared with the parity rates (foreign interest rate plus devaluation) and the foreign financing of the government deficit played the leading roles.

Monetary and Fiscal Policies

During the 1966-82 period, two subperiods with different rates of monetary expansion can be clearly distinguished: 1966-71, when the money supply (M1) grew at an annual rate of 16 percent; and 1972-82, when M1 increased at 24 percent per year (see Table 6).

One distinguishing feature of monetary growth in Colombia during this period is the increase in the monetary base, at 24.4 percent per year, compared with the increase in the money supply at 21 percent per year. This means that the money multiplier continuously contracted, falling from an average of 2.0 percent for 1966-71 to an average of 1.5 for 1972-82 (a 3.4 percent reduction per year for the period as a whole). As a result, the ability of commercial banks to intermediate resources deteriorated considerably, and the spread between borrowing and lending rates by commercial banks increased sharply.

During most of the 1967-82 period fiscal policy was fairly moderate. Between 1967 and 1978 the average annual central government deficit was less than 1 percent of GDP. Subsequently, however, expansive fiscal policy produced a large and growing deficit each year, financed with Central Bank credit and foreign borrowing (Table 7).

Table 4—Real exchange rate index, relative export and import prices, terms of trade, and profitability of exporting, 1967-83

Category	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
	(1975 = 100)																
Real exchange rate																	
Morawetz																	
Ruiz	82.3	89.7	91.4	96.5	100.1	99.8	95.5	94.5	100.0	98.2	83.4	80.7	78.4	77.7	74.5	n.a.	n.a.
Total exports	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100.0	94.5	86.4	87.5	84.6	85.4	78.5	73.7	76.2
Effective minor exports	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100.0	96.9	90.3	92.9	90.1	93.9	93.5	89.9	93.6
Relative price of exports ^a																	
Total	72.5	75.6	73.7	87.1	78.5	84.8	98.0	104.1	100.0	119.8	130.9	104.5	91.1	97.8	78.3	73.5	72.2
Total without coffee	67.8	65.0	65.2	72.4	71.3	75.2	85.5	104.0	100.0	95.3	89.0	79.2	80.5	90.4	81.4	71.9	71.7
Coffee	78.2	87.8	86.0	109.6	89.9	102.7	123.3	104.2	100.0	169.6	245.0	147.5	105.7	108.4	73.3	76.1	72.9
Noncoffee agriculture (02.03,12)	68.5	62.6	67.1	71.2	72.8	85.7	96.3	114.1	100.0	86.6	86.6	66.0	66.1	79.6	69.7	55.0	58.0
Manufacturing (09-11,13-25)	46.9	52.5	50.7	55.5	56.5	64.9	79.1	103.9	100.0	99.1	89.2	82.7	84.0	84.8	81.9	77.3	73.8
Relative price of imports ^b																	
Total imports	81.3	88.0	84.3	82.0	78.6	78.9	83.1	98.2	100.0	95.0	86.7	76.1	76.0	78.6	71.5	65.5	63.8
Broad agriculture (01-03,08,12)	64.4	77.5	71.7	62.0	62.1	63.4	90.5	117.4	100.0	84.1	81.4	46.4	63.0	70.7	60.3	52.7	52.9
Manufacturing (09-11,13-25)	81.5	88.2	84.1	82.5	78.8	78.5	81.5	97.1	100.0	94.9	85.3	77.0	74.6	77.4	70.7	65.1	63.0
Terms of trade	90.7	91.3	94.5	106.1	100.0	107.6	117.9	106.0	100.0	126.1	150.9	137.2	119.9	124.5	109.5	112.5	113.9
Profitability of exporting																	
Agriculture (02.03)	84.8	79.0	78.7	85.0	90.6	99.2	101.5	102.8	100.0	89.4	81.0	78.9	90.8	92.4	93.9	95.6	99.6
Manufacturing (09-11,13-25)	47.4	52.6	51.1	58.5	60.3	68.2	80.1	101.8	100.0	100.8	92.7	90.1	93.0	91.9	91.7	86.5	83.0
Total (01-35)	73.1	74.6	72.6	88.7	80.7	86.1	97.5	103.1	100.0	119.1	131.7	109.8	96.9	103.4	85.8	80.9	79.7

Sources: Real exchange rates are derived from David Morawetz, *Why the Emperor's New Clothes Are Not Made in Colombia*, World Bank Staff Working Paper No. 368 (Washington, D.C.: World Bank, 1980); and Alvaro Ruiz, "La Competitividad de las Exportaciones Menores en el Periodo 1975-1983 y el Deficit en la Balanza de Pagos Registrado entre 1980-1983," *Revista de Planeacion y Desarrollo* 16 (April-September 1984): 2-3. Terms of trade are derived from implicit prices of exports and imports from national accounts in Colombia, Banco de la Republica, *Cuentas Nacionales de Colombia 1967-1969* (Bogotá: Banco de la Republica, 1970); and Colombia, Departamento Administrativo Nacional de Estadística (DANE), *Cuentas Nacionales de Colombia 1970-1983* (Bogotá: DANE, 1984). Relative prices and profitability of exporting for 1970-84 are derived from DANE, *Cuentas Nacionales de Colombia* and for 1967-69 and 1985 from unpublished data provided by DANE.

^a Implicit price of exports/implicit price of nontraded goods.
^b Implicit price of imports/implicit price of nontraded goods.

Table 5—Summary balance of payments, 1968-83

Year	Current Account				Capital Account	Change in Reserves	Level of Reserves
	Trade Account	Services Account	Transfers	Total			
(US \$ million)							
1968	-10.0	-185.0	31.0	-164.0	233.0	69.0	35.0
1969	24.0	-237.0	38.0	-175.0	230.0	55.0	97.0
1970	-14.0	-315.0	36.0	-293.0	329.0	36.0	152.0
1971	-148.4	-340.0	34.1	-454.3	437.2	-17.1	170.4
1972	130.3	-355.1	34.8	-190.0	370.2	180.2	345.2
1973	280.2	-369.6	34.6	-54.8	225.3	170.5	515.9
1974	-15.6	-386.1	51.7	-350.0	258.6	-91.4	429.5
1975	292.6	-445.6	43.7	-109.3	204.0	94.7	547.3
1976	579.0	-430.4	58.1	206.7	431.7	638.4	1,165.9
1977	734.4	-352.6	58.4	440.2	145.9	586.1	1,831.1
1978	642.3	-393.1	72.6	321.8	209.0	530.8	2,479.9
1979	510.3	-120.1	100.8	491.0	1,007.7	1,498.7	4,106.1
1980	-238.2	-85.9	165.3	-158.8	1,615.2	1,465.4	5,415.7
1981	-1,543.5	-594.3	242.9	-1,894.9	2,581.2	686.3	5,630.3
1982	-2,189.2	-872.2	166.7	-2,894.7	2,375.8	-2,142.8	4,890.8
1983	-1,755.3	-1,155.6	173.2	-2,737.7	1,113.9	-1,812.0	3,078.8

Sources: International Monetary Fund, *Supplement on Balance of Payments* (Washington, D.C.: IMF, 1984); and International Monetary Fund, *International Financial Statistics: Supplement on Balance of Payments No. 7* (Washington, D.C.: IMF, 1984). Data on the level of reserves were provided by Colombia, Banco de la República, *Revista del Banco de la República*, various issues.

Notes: The data on level and change of reserves may not be compatible because they are drawn from different sources.

The low deficits of the early 1970s turned into a surplus in 1976-78, partly because of a rise in taxes but also because of a contraction in public expenditures as part of stabilization efforts. High deficits then began in 1979. Public revenues fell because of widespread tax evasion induced by the high tax rates enacted in 1974 and because access to inflationary financing was very easy.¹⁵ When viewed from the consolidated public sector side, between 1977 and 1983 government expenditure increased from 28 to 40 percent of GDP, while revenues only increased from 27 to 31 percent of GDP (see Table 8). As a result, the consolidated public sector deficit increased from 1.2 to 8.6 percent of GDP during that period.

These movements in fiscal policy had their counterpart in money creation and the government's contribution to it. Between 1967 and 1975 the proportion of the deficit financed by money creation was equivalent to 1.0 percent of GDP. It turned negative in 1976-78, and increased sharply in the period 1979-84, reaching an average of 2.2 percent of GDP (see Table 7).

Interest Rates, Devaluation, and Inflation

During the period 1967-83 interest rates experienced a continuous upward movement caused by several factors: the acceleration in domestic inflation, the increase in reserve requirements and forced investments imposed on the commercial banking system, and restrictions on domestic credit. The private sector to limit the effects of

¹⁵ The easy access to inflationary finance was provided by the use of a facility at the Central Bank called the Special Exchange Account. Its sources of revenue were: taxes on coffee exports and profit remittances, interest earned on international reserves, and accounting profits in the purchase and sale of international reserves.

Table 6—Money supply, money base, and money multiplier, 1966-82

Year	Money Supply	Monetary Base	Money Supply/ Monetary Base	Money Supply/ GDP
	(P million)		(percent)	
1966	10,130	4,471	2.27	13.76
1967	11,892	5,514	2.16	14.31
1968	14,217	7,406	1.92	14.74
1969	16,584	8,813	1.88	14.95
1970	19,700	10,957	1.81	14.84
1971	22,324	12,201	1.83	14.32
1972	26,088	14,514	1.80	13.76
1973	32,961	19,147	1.72	13.56
1974	40,819	23,269	1.75	12.66
1975	50,040	28,619	1.75	12.35
1976	64,804	40,730	1.59	12.17
1977	88,488	60,742	1.46	12.36
1978	113,846	81,977	1.39	12.52
1979	141,518	105,931	1.34	11.90
1980	176,488	137,033	1.29	11.18
1981	221,370	167,509	1.32	8.96
1982	271,794	198,725	1.37	9.17

Source: World Bank, *Colombia Economic Development and Policy Under Changing Conditions* (Washington, D.C.: World Bank, 1984), p. 226, Table 6.1; and Banco de la República, computer printout.

Table 7—Central government operations as a share of GDP, 1966-82

Year	Tax Revenue	Revenue from Money Creation	Total Expenditure	Deficit ^a	Government Share/GDP ^a
	(percent)				
1966	8.80	...	9.80	-0.28	1.10
1967	9.20	...	11.40	-0.59	0.40
1968	8.50	...	9.30	-0.84	1.20
1969	9.28	-0.27	9.99	-0.72	0.80
1970	9.35	-0.12	10.31	-0.96	1.30
1971	8.67	-0.18	10.42	-1.76	1.60
1972	8.37	0.00	9.52	-1.15	0.47
1973	7.81	0.33	9.00	-1.19	1.07
1974	8.72	0.29	9.71	-0.99	1.39
1975	8.97	0.20	8.33	0.65	-0.72
1976	8.57	0.29	8.04	0.52	-0.60
1977	8.92	0.33	8.60	0.32	-0.52
1978	8.36	1.28	9.15	-0.79	0.20
1979	8.36	1.25	10.34	-1.97	2.20
1980	7.91	2.43	10.84	-2.94	3.20
1981	7.55	2.71	11.66	-4.11	n.a.
1982	7.10	1.76	11.35	-4.25	n.a.

Sources: Central government operations for 1967-66 are taken from Colombia, Dirección General de Presupuesto, *Boletín 64*, December 1973, pp. 119-123; and for 1970-84, from direct information from Banco de la República, Departamento de Investigaciones Económicas. For the government contribution to the growth of the monetary base, see Robert J. Barro, "El Dinero y la Base Monetaria en Colombia: 1967-1972," *Revista de Planeación y Desarrollo* (April-June 1973): Table 2; and for 1973-81, Colombia, Departamento Nacional de Planeación "La Situación Fiscal de Colombia: 1970-1981," Bogotá, 1982 (mimeographed).

^a The government share in 1967-72 corresponds to the adjusted central government deficit defined in Barro, "Dinero y la Base Monetaria."

Table 8—Consolidated public sector revenues and expenditures, nominal GDP, and revenues and expenditures as a share of GDP, 1966-82

Year	Expenditures	Revenues	Deficit	Nominal GDP	Expenditures/ GDP	Revenues/ GDP	Deficit
	(P million)				(percent)		
1966	20,924	17,920	3,004	83,083	25.2	21.6	3.6
1967	26,812	21,869	4,943	96,422	27.8	22.7	5.1
1968	34,565	25,968	8,597	110,953	31.2	23.4	7.7
1969	40,741	31,491	9,250	132,768	30.7	23.7	7.0
1970	49,287	37,650	11,637	155,886	31.6	24.2	7.5
1971	56,839	44,401	12,438	189,614	30.0	23.4	6.6
1972	61,325	78,590	-17,265	243,160	25.2	32.3	-7.1
1973	81,144	77,944	3,200	322,384	25.2	24.2	1.0
1974	105,351	109,345	-3,994	405,108	26.0	27.0	-1.0
1975	150,448	139,917	10,531	532,270	28.3	26.3	2.0
1976	197,433	178,110	19,323	716,029	27.6	24.9	2.7
1977	256,291	245,378	10,913	909,487	28.2	27.0	1.2
1978	353,545	305,135	48,410	1,188,817	29.7	25.7	4.1
1979	530,145	437,819	92,326	1,579,130	33.6	27.7	5.8
1980	697,756	562,640	135,116	1,982,773	35.2	28.4	6.8
1981	931,794	708,206	223,588	2,497,298	37.3	28.4	9.0
1982	1,213,132	953,132	260,000	3,036,661	39.9	31.4	8.6

Sources: Consolidated public sector revenues and expenditures for 1967-72 are taken from Colombia, Departamento Nacional de Planeación, *Misión Bird-Wiesner, Finanzas Intergubernamentales en Colombia* (Bogotá: Printer Colombiana, 1981), Table II-1; and for 1973-82, from Colombia, Departamento Nacional de Planeación, "Consolidación Financiera del Sector Público Colombiano," Bogotá, 1984 (mimeographed). Nominal GDP is taken from Colombia, Banco de la República, *Cuentas Nacionales de Colombia* (Bogotá: Banco de la República, various years).

the financing of the government deficit via monetary expansion. (This is a classical example of "crowding out".) In addition, rising interest rates on international capital markets were also an important element in pushing domestic interest rates upward.

The 1967-77 period can be characterized as one of low interest rates (with the exception of 1973-74), while the period 1978-83 can clearly be classified as high (see Table 9). It is not mere coincidence that the trend growth rate of the economy dropped sharply in the latter period. As a result of the severe restrictions on capital inflows since 1976 and the reduction in the rate of devaluation, the differential between the domestic and parity interest rates increased strongly between 1975 and 1979. After 1979, the increase in the rate of devaluation, the stabilization of domestic interest rates, and the increase in interest rates in the international capital markets combined to reduce the differential. In 1983 a complete reversal of the situation that existed between 1975 and 1979 took place, and the parity rate turned higher than the domestic one.

Relative Prices

This section examines the behavior of agricultural prices relative to prices in the nonagricultural sector. Since 1970, substantial changes in relative prices have taken place, induced by movements in the country's international terms of trade and domestic economic policies. A complete set of relative prices for agriculture as a whole and for various categories of agricultural products during the period 1970-83 is presented in Table 10.

For this discussion, two classifications of agricultural production have been adopted: the first distinguishes between coffee and noncoffee, and between food, nonfood, and

Table 9—Domestic interest rate, devaluation, interest rate differential, and parity rate, 1967-83

Year	Interest Rate		Devaluation	Interest Differential ^a	Parity Rate ^b	Euro-dollar
	Nominal	Real				
	(percent)					
1967	13.6	4.8	16.9	-7.9	23.3	5.5
1968	13.6	3.8	7.1	-0.3	13.9	6.4
1969	12.9	4.2	5.5	-2.5	15.8	9.8
1970	13.3	2.8	6.9	-2.4	16.0	8.5
1971	16.4	5.3	9.5	-0.2	16.7	6.6
1972	15.6	2.3	9.0	0.5	14.9	5.5
1973	15.8	-3.7	8.8	-2.6	18.9	9.2
1974	30.7	4.2	15.5	1.9	28.2	11.0
1975	27.4	3.7	15.1	3.5	23.1	7.0
1976	21.2	-3.4	10.2	4.2	16.3	5.6
1977	19.8	-7.2	4.5	8.2	10.8	6.0
1978	20.2	2.7	8.0	2.4	17.4	8.7
1979	30.6	5.2	7.3	8.7	20.1	12.0
1980	34.4	5.3	15.7	1.5	32.3	14.4
1981	37.3	11.8	16.0	1.6	35.2	16.5
1982	38.0	10.8	19.0	2.5	34.6	13.1
1983	33.7	14.2	26.3	-3.4	38.4	9.6

Sources: For the Eurodollar rate, International Monetary Fund, *International Financial Statistics Yearbook 1984* (Washington, D.C.: IMF, 1984), United Kingdom page, line 60d; for interest rates for 1968-73, Gabriel Montes and Ricardo Candelo, "El Enfoque Monetario de la Balanza de Pagos: El Caso de Colombia, 1968-1980," *Revista de Planeación y Desarrollo* (May-August 1982); and for interest rates for 1974-83, Patricia Correa, "Determinantes de la Cuenta de Servicios de la Balanza Cambiaria," *Ensayos sobre Política Económica* (December 1984).

Note: For 1967, the interest rate was assumed to be equal to the 1968 rate.

^a Interest differential = $(1 + \text{nominal rate}) / (1 + \text{parity rate}) - 1$.

^b Parity rate = $(1 + \text{Eurodollar}) (1 + \text{devaluation}) - 1$.

nonfood without coffee. The second classifies agriculture as traded and nontraded, and makes a distinction in the traded sector between importables and exportables, the latter comprising the coffee and noncoffee sectors.

The data in Table 10 show a clear pattern. For agriculture as a whole, relative prices increased during 1970-73 and 1975-77, fell during 1973-75, and decreased continuously after 1977. This movement in relative prices is linked to movements in the country's external terms of trade, which are dominated by movements in the price of coffee.

Coffee and Noncoffee. To clarify the movement of relative prices, a distinction is made between coffee and noncoffee agriculture. Then it can be seen that the price of noncoffee agriculture rose between 1970 and 1974 and declined afterwards, with the exception of 1977 when it increased by 6 percent due to a substantial shortfall in trend output. Thus, the underlying forces that reduced the relative price of noncoffee agriculture were present from 1975.

Coffee prices do not show a well-defined trend between 1970 and 1975. Between 1975 and 1977 the price more than doubled, then declined consistently, by 60 percent, until 1983.

The decline in noncoffee agriculture prices began in 1975, but a sharp fall of 10 percent took place in 1978. The largest decline—16 percent—occurred in crops, and the smallest one—3 percent—in animal production. In 1979 there was a further 6 percent reduction in the price of noncoffee agriculture, and for the rest of the period,

Table 10—Relative price index for agricultural output, 1970-83

Item	1970	1971	1972	1973	1974	1976	1977	1978	1979	1980	1981	1982	1983
(1975 = 100)													
Total agricultural output (01,02,03,08,12)	98.2	94.1	99.1	109.5	106.4	111.8	127.4	109.8	95.7	2.0	82.8	82.7	81.7
Noncoffee	92.3	93.4	96.8	105.4	107.5	98.3	103.9	93.8	88.0	85.2	83.0	82.9	82.5
Crops production (02)	97.3	97.0	96.7	102.4	103.2	97.0	99.1	83.3	79.4	77.8	76.7	76.1	74.5
Animal production (03)	88.0	91.2	97.9	110.2	111.3	99.6	107.5	104.3	96.4	88.3	86.4	88.0	86.7
Sugar (12)	82.8	81.6	87.2	88.3	113.9	98.2	120.9	104.5	95.3	120.2	108.9	95.3	110.2
Coffee	112.6	95.9	105.3	120.6	103.3	151.0	202.3	149.5	112.2	106.8	82.5	82.0	79.8
Pergamino coffee (01)	111.4	95.4	102.4	112.8	100.5	135.6	175.3	146.8	116.3	100.7	89.7	84.4	83.5
Processed coffee (08)	113.3	96.2	106.8	124.6	104.8	159.2	222.3	150.8	110.2	109.9	78.0	80.5	77.4
Food	91.9	93.0	96.2	105.2	106.8	97.3	103.1	93.7	87.5	84.4	82.4	82.6	82.4
Nonfood	109.4	96.4	104.8	118.0	105.6	142.4	181.3	140.5	109.7	104.8	83.7	82.7	80.4
Tradables	95.9	98.2	102.7	107.1	114.9	108.6	111.5	94.7	94.6	93.5	89.7	87.8	84.1
Exportables	96.5	89.8	96.6	108.6	106.7	118.2	139.3	118.6	100.9	96.9	85.2	84.7	84.3
Coffee (01,08)	112.6	95.9	105.3	120.6	103.3	151.0	202.3	149.5	112.2	106.8	82.5	82.0	79.8
Noncoffee	81.5	82.4	90.1	100.1	109.9	100.8	110.5	102.3	94.6	91.4	87.8	87.1	88.7
Importables	97.4	94.7	95.3	105.7	105.2	99.7	100.2	88.0	86.9	85.1	85.2	85.0	84.4
Nontraded	102.9	106.9	106.7	112.0	105.5	94.4	98.0	86.9	81.3	77.7	76.0	76.9	74.5
Relative prices within the agricultural sector													
Tradables/nontraded	93.8	84.0	90.6	97.0	101.1	125.3	142.1	136.5	124.1	124.8	112.1	110.1	113.1
Noncoffee tradables/nontraded	83.8	80.5	85.9	90.8	102.9	106.5	109.7	113.0	113.5	115.4	114.5	112.3	117.2
Coffee/nontraded	109.4	89.8	98.7	107.7	97.9	160.0	206.4	171.9	138.0	137.6	108.6	106.5	107.1
Noncoffee exportables/nontraded	79.2	77.1	84.5	89.4	104.2	106.8	112.7	117.7	116.3	117.7	115.4	113.2	119.0
Importable/nontraded	94.6	88.6	89.3	94.4	99.7	105.7	102.2	101.3	106.9	109.6	112.0	110.5	113.3
Coffee/noncoffee agriculture	122.0	102.7	108.8	114.4	96.1	153.7	194.7	159.3	127.5	125.5	99.5	98.8	96.7
Exportable/importable	98.9	93.6	101.7	103.4	101.8	122.8	148.4	142.1	119.3	116.6	100.1	99.5	99.7
Noncoffee exportable/importable	83.7	87.0	94.5	94.7	104.5	101.1	110.4	116.2	108.8	107.4	103.0	102.4	105.0
Food/nonfood	84.0	96.5	91.8	89.1	101.1	68.3	56.9	66.7	79.7	80.5	98.5	99.9	102.6
Food/noncoffee nonfood	95.9	94.7	93.6	98.3	92.9	89.6	92.5	98.9	92.5	90.3	91.8	94.1	98.0
Crops (02)/Animal sector (03)	110.5	106.3	98.7	92.9	92.7	97.5	92.2	79.9	82.3	88.1	88.8	86.5	85.9
Sugar (12)/animal sector (03)	94.0	89.4	89.0	80.1	102.4	98.6	112.4	100.3	98.9	136.1	126.1	108.3	127.2
Sugar (12)/crops (02)	85.0	84.1	90.2	86.2	110.4	101.2	121.9	125.5	120.1	154.5	142.0	125.2	148.0

Source: Derived from Colombia, Departamento Administrativo Nacional de Estadística (DANE), *División de Cuentas Nacionales*, "Working Sheets: 1970-83," Bogotá, 1984.

Notes: This table shows the implicit price of gross value of agricultural output relative to implicit price of gross value of nonagricultural production. The numbers in parentheses are the national account codes for the various components of the agricultural sector.

1980-83, the decline reached 6 percent. As for coffee, after the increase in prices in 1975-77, it fell 26 percent in 1978, a decline that continued, reaching 29 percent between 1979 and 1983.

Food and Nonfood. For the food and nonfood sectors, the pattern of relative price movements is similar to that for coffee and noncoffee agriculture. Excluding the effects of changes in coffee prices in nonfood agriculture, its relative price increased between 1970 and 1974, declined in 1975, rose again in 1976, and fell steadily afterward. Similarly, the price of food increased 16 percent between 1970 and 1974 and, excluding 1977, fell 23 percent between 1974 and 1983.

The fall in the relative price of noncoffee agriculture was unevenly distributed among sectors. Sugar prices do not present a defined trend during the period, and they varied widely as a result of large variations in the international price of sugar. The price of animal production fell 20 percent between 1977 and 1983. The sharpest decline in prices between 1974 and 1983—28 percent—took place in the crops sector. The size of the decline and its permanence most likely exerted a strong negative influence on production in this sector. On the other hand, the decline in the price of crops relative to the price of animal production (most of it livestock) probably drove the price of land downward relative to what it would have been otherwise and may have discouraged the adoption of higher-yield technologies in the livestock sector.

Tradables and Nontradables. Movements in the prices of tradable products are dominated by movements in the price of coffee. Excluding coffee, the relative price of noncoffee tradables rose between 1970 and 1974 and declined afterwards. The price of noncoffee exportables increased 35 percent between 1970 and 1974, fell in 1975, increased in 1976 and 1977, and fell 20 percent between 1977 and 1983. Prices for the importable sector increased 8 percent between 1970 and 1974 and fell 20 percent between 1974 and 1983. Between 1973 and 1983 the largest decline in prices (33 percent) took place in the nontraded sector of agriculture. A tentative explanation for this result is that most output in the nontradable sector of agriculture is composed of food items like potatoes, cassava, and plantain for which the income elasticity of demand is rather low (see Appendix 1). For these products the growth in demand was smaller than the increase in production, especially for those where substantial improvements in productivity occurred (for example, potatoes).

The increase in the prices of noncoffee agriculture between 1970 and 1974 can be explained by more consistent macroeconomic policy management plus some trade liberalization, which led to an increase in the real exchange rate of noncoffee agriculture. The price drop since 1974 can be explained by increases in the terms of trade and in the volume of coffee exports in the second half of the 1970s, plus a large surge in government expenditure in the late 1970s and early 1980s. The monetization arising from the increase in international reserves was partially offset by a central government surplus in 1976-78, which avoided a larger deterioration of the real exchange rate. The large fiscal deficit that began to develop in 1979 became an important factor in maintaining the downward pressure on the relative price of traded commodities after that year.

A MODEL AND EMPIRICAL EVIDENCE

Conceptual Framework

The Colombian economy can be considered a small semiopen economy which is a pricetaker in goods and capital markets. Trade in commodities and the mobility of capital are hampered by restrictions and administrative controls. Therefore, in modeling such an economy, domestic prices are affected by international prices and foreign interest rates, as well as by domestic policies.¹⁶

This chapter examines the effects of an increase in prices and exports of coffee, as well as the effects of growing government expenditures and fiscal deficits, on the competitive position and production of noncoffee tradables, with particular emphasis on agriculture. In order to illustrate the effects of changes in terms of trade and government expenditure on the real exchange rate and the relationship between the prices of tradable and nontradable commodities, a small open economy with three commodities is analyzed. They are nontraded commodities (N), coffee (C), and noncoffee tradables (T).

In this model there are two relative prices: $P_N = P_n/P_t$ and $P_C = P_c/P_t$, where P_n is the price of nontraded commodities, P_c is the price of coffee, and P_t is the price of noncoffee tradables.

It is assumed that the supply of each commodity depends positively on its own relative price, on the factors of production used, and on the available technology (t). It is also assumed that each sector j ($j = N, T$, and C) uses capital (K), land (LA), and labor (L). That is,

$$N_s = N_s(P_N, P_C, L_N, K_N, LA_N, t), \quad (1)$$

where

$$\partial N_s / \partial P_N > 0, \partial N_s / \partial P_C < 0, \partial N_s / \partial L_N, \partial N_s / \partial K_N, \partial N_s / \partial LA_N, \partial N_s / \partial t > 0;$$

$$T_s = T_s(P_N, P_C, L_T, K_T, LA_T, t), \quad (2)$$

where

$$\partial T_s / \partial P_N < 0, \partial T_s / \partial P_C < 0, \partial T_s / \partial L_T, \partial T_s / \partial K_T, \partial T_s / \partial LA_T, \partial T_s / \partial t > 0; \text{ and}$$

$$C_s = C_s(P_N, P_C, L_C, K_C, LA_C, t), \quad (3)$$

where

$$\partial C_s / \partial P_N < 0, \partial C_s / \partial P_C > 0, \partial C_s / \partial L_C, \partial C_s / \partial K_C, \partial C_s / \partial LA_C, \partial C_s / \partial t > 0.$$

¹⁶ The model presented in this section is based on Rudiger Dornbusch, *Open Economy Macroeconomics* (New York: Basic Books, 1980), chapters 6, 7, 10, and 11; Carlos A. Rodríguez, "Gasto Público, Deficit y Tipo Real de Cambio: Un Análisis de sus Interrelaciones de Largo Plazo," *Cuadernos de Economía* 57 (August 1982): 203-216; Jacob Frenkel and Michael Mussa, "Asset Markets, The Exchange Rate and the Balance of Payments: The Reformulation of Doctrine," *Handbook of International Economics*, ed. R. Caves and R. Jones (Amsterdam: North Holland, 1985); and W. Max Corden and J. Peter Neary, "Booming Sector and Deindustrialization in a Small Open Economy," *Economic Journal* 92 (December 1982): 825-848.

In equation (1) the output of nontraded goods increases with an increase in its relative price, while in equation (2) the output of noncoffee tradables declines as the relative price of nontradables rises. In equation (3) the output of coffee increases as the relative price of coffee rises. An increase in the price of coffee reduces the *combined* output of nontraded goods and noncoffee tradables, but the effect on the output of each of these commodities is not clear because it depends on the relative factor intensities of the tradable and nontraded sectors.¹⁷ For purposes of this exposition, it is assumed that an increase in the price of coffee tends to reduce the output of both tradable and nontraded commodities.

Total aggregate supply (total income) measured in terms of noncoffee tradables is

$$Y = N_s P_N + T_s + C_s P_C. \quad (4)$$

To simplify the exposition, on the demand side it is assumed that all coffee production is exported, and that changes in the price of coffee do not affect the demand for tradables and nontraded goods, as far as the substitution effect goes.¹⁸ The price of coffee affects the demand for tradable and nontraded goods via changes in income and expenditure, which are positively related to the price of coffee. In other words, the demand for tradables and nontraded goods can be expressed as a function of one relative price, that of noncoffee tradables, and of aggregate expenditure. It is assumed that the demand for nontraded goods increases with decreases in price and increases in expenditure. On the other hand, the demand for noncoffee tradables increases when the price of nontraded goods and expenditures rise. The demand for nontraded goods and noncoffee tradables can then be expressed as follows:

$$N_d = N_d(P_N, E), \quad (5)$$

where

$$(\partial N_d / \partial P_N) < 0, (\partial N_d / \partial E) > 0; \text{ and}$$

$$T_d = T_d(P_N, E), \quad (6)$$

where

$$(\partial T_d / \partial P_N) > 0, (\partial T_d / \partial E) > 0,$$

where E stands for total expenditure.

Equilibrium in the market for nontraded goods is established when demand equals supply. That is,

$$N_s = N_d. \quad (7)$$

Equilibrium in the traded goods market occurs when there is equilibrium in the nontraded goods sector and the current account equals zero (income equals expenditure). For equilibrium in the traded goods market to exist, it is necessary that

¹⁷ For an exposition of the possible effect on the output of nonbooming sectors of an increase in the price of the main export sector, see Corden and Neary, "Booming Sector and Deindustrialization."

¹⁸ This assumption is reasonable because about 85 percent of coffee output is exported and the own-price elasticity of demand for coffee is very low.

$$T_s + P_C C = T_d. \quad (8)$$

Effects of Changes in Coffee Price

From the above set of equations, what happens to the real exchange rate when the price of coffee goes up can be examined. With the level of resources for the economy held constant, the market for nontraded goods is looked at first. On the supply side, an increase in the price of coffee will draw resources out of the nontraded goods sector, thereby creating an excess demand for nontraded commodities. On the demand side, an increase in the price of coffee increases the demand for nontraded goods on account of its effect on real income and hence, on expenditure. As a result, an increase in the price of coffee will tend to create an excess demand in the nontraded goods market, thereby increasing their price.

In the tradable goods market, an increase in the price of coffee reduces the supply of noncoffee tradables as resources are taken away by coffee. This resource movement effect creates an excess demand for tradables (combined output of coffee and noncoffee) and tends to reduce the price of nontraded goods. However, this is only one of the effects of the increase in the price of coffee. On the demand side, an increase in the price of coffee increases income and hence expenditure, thus driving up the demand for noncoffee tradables. Therefore, the net effect of the increase in the price of coffee is to increase the excess demand for noncoffee tradables, thereby pushing the price of nontraded goods downward.

Moving now to the effects of coffee on the tradable market, there are two. First, the increase in the price of coffee increases the total supply of tradables by an amount equal to the increase in the price of coffee. Second, the increase in the price of coffee draws resources toward coffee production but takes them away from the noncoffee tradable and nontraded sectors. Presumably, the new allocation of resources is better than the old one, which means that the overall effect of the increase in the price of coffee is to increase the supply of tradables. Thus, the two effects—price and quantity—tend to increase the supply of tradables. The expenditure effect on coffee does not take place because it is assumed that all coffee production is exported.

To summarize, in the case of tradables, an increase in the price of coffee increases the excess demand for noncoffee tradables and the excess supply of coffee.¹⁹ The net effect is not defined. However, there is a strong presumption that the increase in the price of coffee tends to create an excess supply of tradables, thus driving the price of noncoffee tradables downward. This is presumed because coffee draws resources out of both the noncoffee tradable and the nontraded sectors; therefore the increase in coffee output is larger than the decline in the output of noncoffee tradables. On the other hand, the increase in demand for noncoffee tradables due to the expenditure effect is smaller than the increase in the value of coffee exports because part of the increase in income (equal to the increase in the value of coffee exports) is spent on nontradables. Therefore, an increase in the price of coffee tends to increase the price of nontradables relative to the price of noncoffee tradables.

Government Expenditure, Interest Rates, and the Real Exchange Rate

Government Expenditure. In the discussion on the effects of an exogenous change in the external price of coffee, it was mentioned that an increase in the price of coffee

¹⁹ In the case of coffee, excess supply and supply are the same because it is assumed that there is no domestic consumption of coffee.

affected total expenditure via its indirect impact on income. In this section the effects on relative prices of changes in government expenditure are explored.

To analyze the effect of changes in government expenditure on relative prices, it is assumed that total expenditure is divided between government expenditure (G) and private expenditure (E_p). E_p depends positively on disposable income (Y_d) and negatively on the real interest rate (r). That is,

$$E = E_p + G; \quad (9)$$

$$E_p = E(Y_d, r) = E(Y - I, r), \quad (10)$$

where I is government revenue from taxes;

$$\partial E_p / \partial (Y - I) > 0; \text{ and } \partial E_p / \partial r < 0. \quad (11)$$

The government, in turn, purchases nontradable (G_N) and noncoffee tradable goods (G_T).²⁰

Equilibrium in the market for nontradable goods is established when demand equals supply. That is,

$$N_s = N_d + G_N, \quad (12)$$

where N_d now represents the demand of the private sector for nontradable goods.

Equilibrium in the traded goods market occurs when there is equilibrium in the nontraded goods sector and the current account equals zero (income equals expenditure). To have equilibrium in the traded goods market, it is necessary that

$$T_s + P_C C = T_d + G_T, \quad (13)$$

where T_d now represents the demand of the private sector for noncoffee tradables.

It is assumed that the government finances its expenditure entirely with taxes. That is,

$$G = G_T + G_N = I. \quad (14)$$

An increase in government expenditure increases the demand for nontraded goods if the government's propensity to purchase them is higher than the private sector's. In that case, the price of noncoffee tradables will increase. This result holds whether viewed from the nontraded or the traded goods markets. The initial statement corresponds to the analysis from the nontraded viewpoint. Viewed from the perspective of the market for tradables, the increase in the government demand for tradables is less than the reduction in the demand for tradables by the private sector induced by the increase in taxes. Thus, an excess supply of tradable goods develops, and to have equilibrium in that market, the price of nontraded commodities must increase.

²⁰ To assume that the government only purchases noncoffee tradables and nontraded commodities might appear somewhat unrealistic in the Colombian case because the government is an important purchaser of coffee via the National Coffee Fund (NCF). Because coffee purchased by the NCF is exported, however, it can be interpreted that NCF only acts as an export agent of domestic producers, in which case the assumption is justified.

When government expenditure is financed with external loans and money creation, then the budget constraint of the government is given by

$$G = I + FB + B_G, \quad (15)$$

where FB stands for net foreign borrowing and B_G is money creation that finances government expenditure.

If the government's propensity to spend on traded and nontraded commodities is independent of the method of financing, and if the government's marginal propensity to spend on nontraded goods is larger than that of the private sector, then an increase in government expenditure will increase the price of nontraded goods, no matter whether it is financed with foreign borrowing or credit from the Central Bank.

The effect of government expenditure on relative prices is smaller if the public considers that taxes have to be increased to pay the government's external debt. A similar reasoning applies if Central Bank credit to the government has to be repaid in the future. Thus, the public would discount future taxes and adjust its consumption correspondingly. In this case, the situation is the same as the one in which all government expenditure is financed with taxes, and the extent of the effects of such expenditure depends on the relative size of the government and private sector propensities to spend on nontraded commodities.

For most of the period under analysis, the Colombian public sector ran a deficit, which was financed in part with domestic savings, in part with money creation, and in part with foreign loans. Thus, the pressures on the market for nontraded goods created by increases in government expenditure did exist, thereby producing an excess demand for nontraded commodities that pushed their relative price up. Therefore, a positive effect of government expenditure on the price of nontraded goods should be expected.

Interest Rates. Interest rates are the link between savings and investment. Savings are used to finance the government deficit and investment, and the latter is part of the process of capital accumulation, which will be dealt with in the following section. Here, the impact of changes in the interest rate on the relative price of nontraded commodities is discussed.

Looking at the market for nontraded commodities, an exogenous increase in the interest rate reduces expenditure and the demand for nontraded goods, thereby creating an excess supply that drives their price downward. On the other hand, looking at the market for noncoffee tradables, a higher interest rate reduces expenditure and creates an excess supply, thus driving the price of nontraded goods up. In other words, the final effect of changes in the interest rate on the relative price of nontraded goods can be positive or negative, because it depends on the relative size of the excess supplies of nontraded and tradable goods.

However, if the nontraded goods sector is composed mainly of services, where changes in the interest rate probably have little or no effect on expenditure, and the traded goods sector is composed of commodities, where the effect of the interest rate is considerable, an increase in the interest rate will probably increase the relative price of nontraded goods. According to the classification of the various sectors presented in Appendix 1, the nontraded goods sector is composed to a large extent of services, whereas the traded goods sector is composed mainly of manufactured and agricultural products. Thus, there is a strong presumption that increases in the interest rate will lead to an increase in the relative price of nontraded goods.

Growth of Resources

Relative prices can be affected by the growth of capital and labor and by technical change. In the same way, the stock of capital, the labor force, and technical change vary with changes in relative prices. A detailed treatment of these interactions is beyond the scope of this report, but it is worth pointing out some aspects that are relevant for determining the impact on relative prices of changes in total output.²¹

The growth of resources increases the output and the demand for all commodities. The final effect of growth on relative prices depends on the relative growth of demands and supplies of coffee, nontraded, and noncoffee tradable commodities. To simplify the exposition, on the output side the discussion is carried on in terms of the effects of overall growth on the output of each sector. These changes in sectorial output are then compared to changes in the demand for each product due to economic growth.

Briefly, growth may affect relative prices in the following ways. From the viewpoint of the noncoffee tradable sector, a faster increase in demand than in supply may generate a deficit in the current account, which would have to be closed by a fall in the relative price of nontraded commodities. But, viewed from the coffee sector side, when coffee output grows faster than the output of noncoffee tradables, a potential surplus in the current account develops, and the relative price of nontraded goods will probably increase. Viewed from the nontraded goods sectors' side, the price of noncoffee tradables tends to increase if the demand for nontraded goods increases faster than its supply. The final effect on relative prices will depend on the relative size of these forces. The relative price of nontraded goods will increase when three conditions are met: first, the demand for nontraded goods increases faster than its supply; second, the output of noncoffee tradables increases faster than its demand; and third, the output of coffee increases faster than that of noncoffee tradables.

In sum, the relative price of nontraded goods depends on four variables: the growth of output, the price of coffee relative to noncoffee tradables, the real interest rate, and government expenditure. It is expected that an increase in government expenditure and the price of coffee will increase the price of nontraded goods if the former is biased toward nontraded goods and if the latter increases real income and, hence, expenditure. No strong presumption exists on the effects of economic growth and interest rate changes on the relative price of nontraded goods. However, if the nontraded goods sector is composed mainly of services, then an increase in interest rates will tend to increase its relative price.

Monetary Dynamics and Capital Inflows

To introduce monetary aspects in this model, the following demand for money function is postulated:

$$M^d/P = L(i, Y), \quad (16)$$

where

$$(\partial L / \partial i) < 0, \text{ and } (\partial L / \partial Y) > 0,$$

where i is the nominal interest rate, and P is the general price level. Equilibrium in the money market occurs when the supply of money, M^s , equals the demand for money, M^d . That is,

²¹ An application of these interactions for Argentina can be found in Domingo Cavallo and Yair Mundlak, *Agriculture and Economic Growth in an Open Economy: The Case of Argentina*, Research Report 36 (Washington, D. C., IFPRI, 1982).

$$M^s = M^d = PL(i, Y). \quad (17)$$

Changes in the money supply take place via changes in domestic credit and changes in international reserves.

As postulated at the beginning of this chapter, the Colombian economy can be thought of as a semiopen economy, where government regulations restrict capital mobility but where domestic interest rates, nevertheless, follow the parity rate, $i^*(1 + \hat{e})$, where i^* is the foreign interest rate and $\hat{e}$, the rate of devaluation.²² If this is so, the level of the domestic interest rate depends on both external and internal factors. This means then that the adjustment is not instantaneous and, at least in the short run, monetary policy has an impact on the economy. In the long run the domestic interest rate adjusts to the parity rate.

It is also assumed that the government follows some rule to fix the evolution of the exchange rate, but this information is exogenous to the model. The adjustment of the domestic interest rate to changes in domestic and external factors takes place through a coefficient θ per unit of time on the external factors and $(1 - \theta)$ on the internal factors. The latter is given, in turn, by the excess demand for money. Hence, the nominal interest rate is given by

$$i = \theta[i^*(1 + \hat{e})] + (1 - \theta)(M^d/P - M^s/P). \quad (18)$$

Replacing equation (16) in (18), gives

$$i = \theta[i^*(1 + \hat{e})] + (1 - \theta)l(i, Y, M_s/P); \quad (19)$$

and

$$i = i(\theta, i^*, \hat{e}, Y, M^s/P), \quad (20)$$

where

$$\partial i / \partial i^* > 0, \partial i / \partial \hat{e} > 0, \partial i / \partial Y > 0, \partial i / \partial (M^s/P) < 0.$$

Equation (20) represents the evolution of the domestic asset market in the short run, where the interest rate will depend negatively on the real quantity of money and positively on the external rate of interest, real income, and the rate of devaluation. In the long run, the disequilibrium in the money market disappears ($M^d = M^s$), and the second term of the right-hand side of equation (18) becomes zero. Moreover, in the long run, θ tends to 1 and i tends to the parity rate $i^*(1 + \hat{e})$.

Equations (7) and (8), denoting equilibrium in the traded and nontraded goods markets, can now be combined with equation (19) to obtain a better idea of the forces at hand. Equation (8) now includes the capital flows (K) induced by the difference between the domestic and parity rates. Defining K as

$$K = f[i/i^*(1 + \hat{e})] = f(\lambda), \quad (21)$$

²² See, for example, Sebastian Edwards, "Money, the Rate of Devaluation, and Interest Rate in a Semi-Open Economy: Colombia, 1968-1982," *Journal of Money, Credit and Banking* 17 (February 1985): 59-68; and Sebastian Edwards and Mohsin Khan, "Interest Rate Determination in Developing Countries: A Conceptual Framework," *IMF Staff Papers* 32 (September 1985): 377-404.

where

$$\lambda = i/i^*(1 + \hat{e}),$$

and

$$dK/d\lambda > 0.$$

Equation (8), which shows the budget constraint in the traded goods market has to be modified to

$$T_s + P_C C + K = T_d. \quad (22)$$

Equation (22) represents equilibrium in the balance of payments. Once this is obtained, the effects of terms-of-trade changes and variations in government expenditure on relative prices can be analyzed. Graphical analysis is used to examine the effect of such changes.

Graphical Analysis

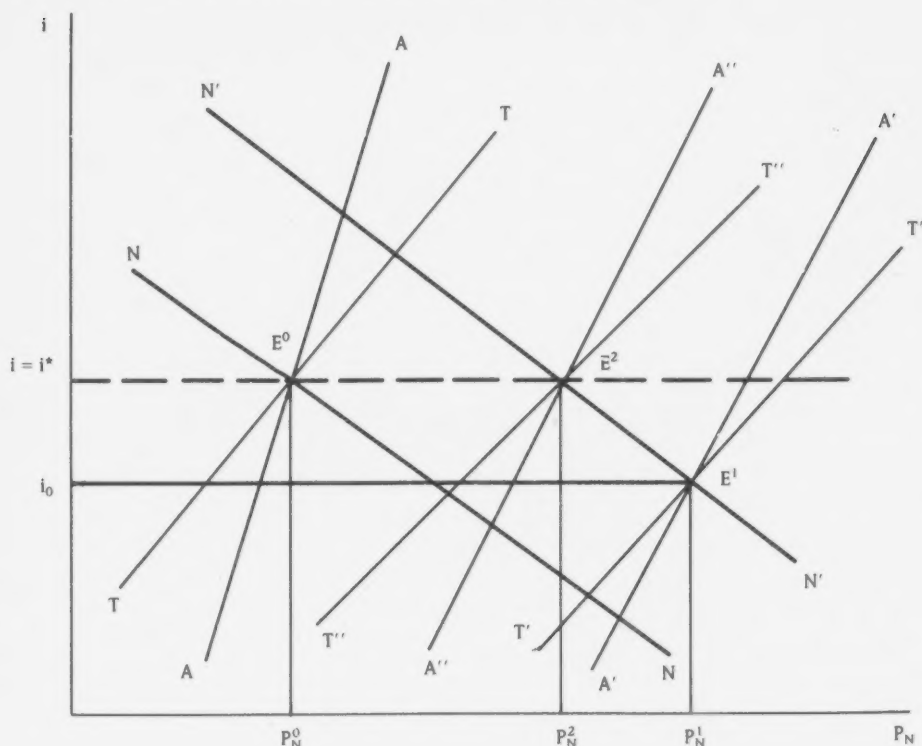
The graphical analysis is based on equations (8), (20), and (22), which represent equilibrium in the nontraded goods, assets, and tradable goods markets, respectively.

For simplicity, it is assumed that the exchange rate is fixed and that the expected rate of inflation is zero ($\pi^e = 0$). Then, as a result of these assumptions, $i = r = i^*$. In Figure 2, where $r = i$ is measured in the vertical axis and P_N in the horizontal axis, there are three schedules. The curve NN represents equilibrium in the nontraded goods market. It has a negative slope because an increase in P_N creates an excess supply of nontraded commodities, which is eliminated with an increase in expenditure via a reduction in the interest rate. The curve TT has a positive slope because an increase in the interest rate reduces absorption and tends to create a balance-of-payments surplus; to eliminate the surplus, an increase in P_N is required. A capital inflow requires an increase in the relative price of nontraded goods to maintain balance-of-payments equilibrium and, therefore, moves the curve TT to the right. Finally, the curve AA represents equilibrium in the asset market and, from equation (20), it has a positive slope.

The working of the model can be illustrated by looking at the effect of an increase in the price of coffee. Starting from an initial equilibrium position in E^0 , with $i = i^*$, an increase in the price of coffee increases real income, creates an excess demand for nontraded goods, and shifts the NN schedule to the right, to $N'N'$. The TT curve has two forces operating in opposite directions. On the one hand, the increase in real income creates an excess demand for tradables that has to be eliminated by a reduction in the price of nontraded goods; for this reason the TT curve has to shift to the left. On the other hand, a higher price of coffee increases the inflow of foreign exchange and creates an excess supply in the traded goods market. The increase in real income due to a rise in coffee prices, $dY = P_N dN_s + dT_s + P_C dC_s + C_s dP_C$, is smaller than the increase in foreign exchange earnings, $dT_s + P_C dC_s + C_s dP_C$, which means that expenditure on noncoffee tradable commodities increases by less than the rise in foreign exchange earnings. Therefore, an increase in coffee prices creates an excess supply in the market for tradable goods and shifts TT to the right, to $T'T'$, and pushes P_N up.²³

²³ The reason why real income increases by less than foreign exchange earnings is that income increases less than the expansion of coffee output because the output of nontraded and noncoffee tradable goods declines by the resource movement effect.

Figure 2—Effects of an increase in the price of coffee

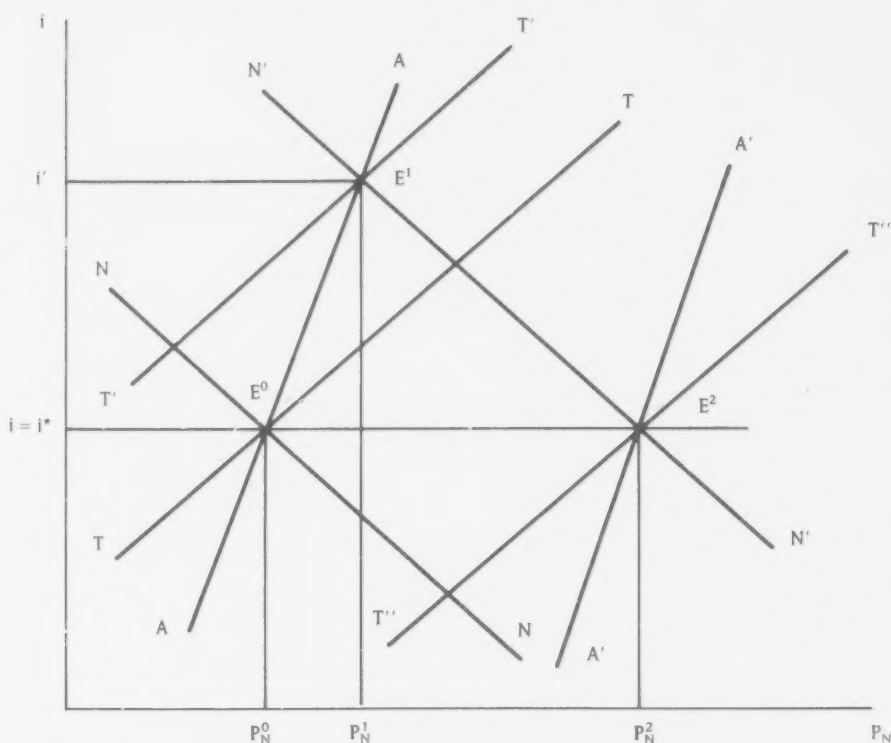


Due to the increase in the money supply induced by the trade surplus, AA shifts to the right and tends to lower interest rates. The short-run equilibrium is at E^1 with a higher $P_N(P_N^1)$, and a lower interest rate, i_0 .

However, because i_0 is lower than i^* , there is a capital outflow that reduces the money supply and shifts $T'T'$ to $T''T''$ and $A'A'$ to $A''A''$. The long-run equilibrium position is at E^2 , with a relative price P_N^2 lower than P_N^1 , and interest rate i_0 . Then, in the short run P_N will "overshoot," and in the long run, equilibrium P_N will be determined by real forces (real income, the external terms of trade, and the external real rate of interest).

The effects of fiscal policy can also be looked at graphically, assuming that there is an increase in government expenditure financed with taxes (see Figure 3). The assumptions that government expenditure is biased toward domestic goods and that private-sector expenditure is biased toward traded goods are maintained. The initial equilibrium position is E^0 . An increase in government expenditure shifts the NN curve to the right, to $N'N'$, and the TT curve to the left, to $T'T'$. The two curves, $T'T'$ and $N'N'$ intersect at E^1 , at a higher interest rate, i_1 . A higher domestic interest rate produces a capital inflow, and the real quantity of money increases, thus reducing the rate of interest. The higher capital inflow moves the $T'T'$ curve to the right, and the higher quantity of money does the same thing to the AA curve. The movement of the curves AA and

Figure 3—Increase in government expenditures financed by taxes



$T'T'$ to the right continues until a new equilibrium position is attained at P_N^2 , higher than the initial one (P_N^0). In this case, an increase in government expenditure increases P_N , and the production of tradables is discouraged.

Empirical Results

To examine the effects of terms-of-trade changes and government expenditure on the real exchange rate, a real exchange rate equation (price of tradables/price of nontradables) is estimated. The real exchange rate is determined by the external terms of trade, the size of government expenditure relative to GDP, per capita real income, and the real interest rate. Government expenditure is taken relative to GDP because the important thing in determining the influence of government on relative prices is how its spending changes *in relation to* GDP rather than its absolute size. Real income is on a per capita basis because it serves as an overall measure of the extent of capital accumulation over the period and also because it is a better measure of the relative growth of aggregate demand.

An estimation of the demand for money is also presented because variations in excess demand for money affect expenditure and relative prices via the impact on interest rates.

For the empirical analysis, ordinary least squares regressions are run, and a correction for autocorrelation is done when it is present.

Relative Prices of Traded and Nontraded Commodities

The main thrust of the model presented in the first part of this chapter is the prediction that, as a result of an increase in the terms of trade (mainly an increase in the price of coffee) and an increase in government expenditure (biased toward domestic goods), the exchange rate for noncoffee sectors appreciated. In other words, the price of tradables over noncoffee tradables decreased. The estimating equation of the real exchange rate for the period 1967-83 is as follows:

$$\log P_N = \pi_0 + \pi_1 R + \pi_2 \log PCGDP + \pi_3 \log P_C + \pi_4 G (\text{or } D) + u, \quad (23)$$

where

log	= natural logarithm
P_N	= price of nontraded goods relative to the price of noncoffee tradables,
R	= real interest rate,
PCGDP	= per capita real GDP,
P_C	= price of coffee relative to the price of noncoffee tradables,
G	= consolidated public-sector expenditure relative to nominal GDP,
D	= consolidated public-sector deficit relative to nominal GDP, and
u	= error term.

The estimated equations are presented in Table 11. The coefficients are significant, and the signs for the government variables (G or D) and terms of trade tend to support the hypothesis that an improvement in the terms of trade and an increase in government expenditure increase the relative price of nontraded goods. The negative effect of government expenditure on the price of noncoffee tradables also lends support to the idea that the government's propensity to spend on nontraded commodities is higher than its propensity to spend on traded commodities.

It is interesting to note that the interest rate has a positive effect on the price of nontraded goods. This indicates that policies that increase real interest rates lead, in the medium run, to a reduction in the real exchange rate, other things remaining constant. This positive effect of the interest rate on the relative price of nontraded goods is also in agreement with the presumption that increases in the interest rate will increase relative prices.

Table 11 also presents estimates based on equation (23) but for three different sets of relative prices used as dependent variables. These prices are noncoffee exportables, noncoffee agricultural exportables, and noncoffee agricultural tradable goods relative to the price of nontradables. These results support the argument of this chapter that improvements in terms of trade and increases in government expenditure reduce the real exchange rate for the noncoffee tradable sector in general as well as for the agricultural sector. For this set of regressions (equations 4-8) the variable representing

Table 11—Determinants of relative prices of noncoffee tradable and agricultural tradable commodities

Dependent Variable/ Period	Constant	Log Per Capita GDP (T-1)	Real Interest Rate (T-1)	LPC (T-1)	LTTBS (T-1)
1. LPNC (1969-83)	4.2810 (33.1333)	-0.2567 (-6.8147)	0.009 (6.4617)	0.1952 (6.6509)	...
2. LPNC (1968-83)	4.3518 (25.8354)	-0.1471 (-4.125)	0.0065 ^a (2.5922)	0.13977 (3.0395)	...
3. LPXNC (1968-83)	4.9487 (23.634)	0.2347 (5.4009)	-0.0071 ^a (-2.589)	-0.1828 (-3.4196)	...
4. LPXNC (1968-83)	5.484 (7.901)	0.716 (3.1705)	-0.0217 (-3.175)	...	-0.6084 ^a (-2.296)
5. LPXANC (1969-83)	5.3618 (9.339)	0.9799 (5.612)	-0.0203 (-3.834)	...	-0.6724 (-3.3769)
6. LPXANC (1968-83)	5.4419 (10.347)	0.8200 (4.691)	-0.0239 (-4.799)	...	-0.712 (-3.396)
7. LPTANC (1969-83)	5.6117 (10.951)	0.8029 (4.922)	-0.0168 (-3.571)	...	-0.6208 (-3.456)
8. LPTANC (1969-83)	5.9800 (15.259)	0.7415 (5.8609)	-0.0217 (-5.5947)	...	-0.7273 (-4.8663)

Dependent Variable/ Period	Government Variable				R ² Adjusted	Auto- correlation	Durbin Watson Statistic
	G(T-1)	D(-1)	G	D			
1. LPNC (1969-83)	0.42597 (3.5772)	...	...	...	0.911	0.34 (1.1660)	2.272
2. LPNC (1968-83)	...	0.359 (2.6440)	...	...	0.769	...	1.512
3. LPXNC (1968-83)	-0.4794 ^a (-2.368)	...	...	...	0.6506	...	2.208
4. LPXNC (1968-83)	...	-0.6816 ^b (-1.664)	...	...	0.783	...	1.731
5. LPXANC (1969-83)	...	...	-1.1645 (-2.9747)	...	0.865	0.1601 (0.421)	1.588
6. LPXANC (1968-83)	...	...	...	-0.701 ^a (-2.415)	0.822	...	2.12
7. LPTANC (1969-83)	...	...	-1.1811 (-3.206)	...	0.852	0.2134 (0.447)	1.45
8. LPTANC (1969-83)	...	...	...	-0.9227 (-4.005)	0.852	-0.4696 (-1.513)	2.15

Notes: LPNC is the log of the price of nontraded goods over the price of coffee. LPXNC is the log of the price of noncoffee exportables over the price of nontraded goods. LPXANC is the log of the price of noncoffee agricultural exports over the price of nontraded goods. LPTANC is the log of the price of noncoffee agricultural tradables over the price of nontraded goods. LPC is the log of the price of coffee over the price of noncoffee tradables. LTTBS is the log of the price of exports of goods and services over the price of imports of goods and services. Unless otherwise indicated, variables are significant at the 99 percent level. The numbers in parentheses are t-statistics. G is government expenditures and D is the government deficit. T-1 indicates a time lag of one year.

^a Significant at 98 percent.

^b Significant at 90 percent.

terms-of-trade changes is measured by the implicit price of exports of goods and services divided by the implicit price of imports of goods and services.

Relative Prices of Agricultural Output and Nontraded Commodities

Here equation (23) is used to explain the determination of relative prices for broad aggregates of agricultural products for the period 1970-83. The years 1967-69 are excluded because the information required to construct the relevant price indexes is not available. Relative prices in agriculture are measured as the ratio of the implicit price of gross output to the implicit price of nontraded goods in the nonagricultural sector.

Equation 23 is used because the level of aggregation permits it. In other words, the relative prices of agricultural products are explained by the interest rate, the terms of trade, real per capita income, and government expenditure. The estimated equations are presented in Table 12.

The first three equations in Table 12 are the estimated equations for relative prices for total agriculture. All the variables have the expected sign and except for real per capita income are significant at the 99 percent level. The nonsignificance of real per capita income arises from its opposite impact on the price of nontraded and traded goods within agriculture: negative for the first group of commodities and positive for the second. The estimated value of the coefficient for the real interest rate indicates that an increase of 1 percentage point in the interest rate produces a 2.3 percent decline in the relative prices of agricultural products. Therefore, the large increase in interest rates in the external markets in the late 1970s and early 1980s and the internal policies that led to an increase in interest rates seem to have been important factors negatively affecting agricultural incentives.

The effects of terms-of-trade changes are felt positively in the present period but negatively in the following period. This is because this set of relative prices includes coffee, which composes one third of agricultural output. This means that the Dutch-disease effect of an improvement in terms of trade (essentially of increases in coffee prices) is felt one period after this improvement has taken place. It is important to note the high absolute value of the coefficient for the size of the public-sector variable, larger than one. This means that a 1 percentage point increase in the size of the public sector reduces the relative price of agricultural output by more than 1 percentage point. This is particularly important between 1978 and 1983, when the size of the public sector increased from 29 to 39 percent of GDP. Therefore, a great proportion of the loss of competitiveness of Colombian agriculture in the late 1970s can be traced to the substantial increase in government expenditure during this period.

Equations 4 and 5 of Table 12 show the results of estimation for the relative price of noncoffee agriculture. Real per capita income is not very significant, but the rest of the variables are significant to at least a 98 percent confidence level. The nonsignificance of real income arises from its opposite effect on traded and nontraded commodities, as shown below.

Equations 6 and 7 report the results for the tradable sector of noncoffee agriculture, equations 8 and 9 present the results for the exportable sector of agriculture, and equations 10 and 11 for the importable sector of agriculture. Equations 12 and 13 present the results for the tradable part of the food sector. In this set of equations all the explanatory variables are significant and have the expected sign, and the results are similar to the ones reported in equations 4 and 5 and in Table 11.

Table 12—Determinants of relative prices in the agricultural sector

Dependent Variable/ Period	Constant	Log Per Capita GDP (T-1)	Real Interest Rate (T-1)	LTTBS		Government Variable			R ² Adjusted	Autocor- relation	Durbin- Watson Statistic
				(T)	(T-1)	G(T-1)	G	D			
1. LPAG (1970-83)	5.9264 (6.242)	0.2697 (1.1210)	-0.0292 (-4.7588)	0.5077 (3.3422)	-0.9372 (-3.713)	...	...	...	0.88	...	2.3
2. LPAG 1970-83	4.9301 (8.875)	...	-0.0158 (-4.281)	0.6155 (5.554)	-0.6069 (-5.521)	-1.1818 ^a (-2.657)	...	...	0.92	...	2.1
3. LPAG 1971-83	5.1414 (9.943)	...	-0.02 (-6.841)	0.5925 (5.062)	-0.6936 (-6.718)	...	...	-0.7585 ^a (-2.569)	0.93	-0.3311 (-0.8552)	2.2
4. LPAGNC (1971-83)	7.5903 (15.2805)	0.249 ^b (1.835)	-0.0199 (-4.581)	...	-0.7759 (-4.596)	...	...	-0.9529 (-3.196)	0.90	-0.418 (-1.3)	2.6
5. LPAGNC 1971-83	7.43784 (12.821)	0.2671 ^c (1.6709)	-0.0155 (-2.947)	...	-0.6900 (-3.609)	...	-1.55 ^a (-2.806)	...	0.90	...	1.8
6. LPTANI (1971-83)	6.5274 (9.3807)	0.66 ^a (2.818)	-0.019 (-3.211)	...	-0.7337 (-3.268)	...	-1.0894 ^c (-2.169)	...	0.83	0.1743 (0.719)	1.8
7. LPTANI (1971-83)	6.4912 (12.254)	0.6806 (4.2706)	-0.0228 (-4.583)	...	-0.7992 (-4.136)	...	...	-1.055 (-3.332)	0.82	-0.393 (-1.088)	2.1
8. LPXANI (1970-83)	6.1034 (8.375)	0.954 (4.374)	-0.0282 (-4.624)	...	-0.8798 (-3.446)	...	...	-0.89 ^a (-2.492)	0.82	...	2.3
9. LPXANI (1971-83)	6.1464 (8.6208)	0.9528 (4.849)	-0.023 (-3.538)	...	-0.816 (-3.472)	...	-1.2658 ^a (-2.502)	...	0.84	...	1.6
10. LPMAG (1971-83)	7.9733 (21.166)	0.2822 ^a (2.698)	-0.0172 (-5.077)	...	-0.8793 (-6.714)	...	...	-0.8968 (-4.156)	0.91	-0.611 ^b (-2.11)	2.4
11. LPMAG (1970-83)	7.5693 (13.683)	0.3458 ^b (2.241)	-0.0127 ^b (-2.382)	...	-0.7649 (-3.962)	...	-1.2058 (-3.046)	...	0.87	...	2.1

(continued)

Table 12—Continued

Dependent Variable/ Period	Constant	Log Per Capita GDP (T-1)	Real Interest Rate (T-1)	LTTBS		Government Variable		R ² Adjusted	Autocor- relation	Durbin- Watson Statistic
				(T)	(T-1)	G(T-1)	D			
12. LPAGFT (1970-83)	6.458 (11.181)	0.6282 (3.634)	-0.0223 (-4.619)	...	-0.7633 (-3.771)	...	-0.8817 (-3.114)	0.84	...	2.4
13. LPAGFT (1971-83)	6.301 (8.635)	0.5842 ^b (2.16)	-0.0168 (-2.932)	...	-0.6387 ^b (-2.806)	...	-1.145 ^a (-2.217)	0.83	0.304 (0.535)	1.6
14. LPC1 (1971-83)	1.2608 ^b (1.994)	...	-0.0237 (-4.948)	1.8985 (12.06)	-1.0598 (-7.197)	-1.6502 (-2.958)	...	0.96	-0.473 (-1.304)	1.9

Notes: Unless otherwise indicated, variables are significant at the 99 percent level. Log TTBS = terms of trade, G = consolidated government expenditure relative to nominal GDP, D = consolidated government deficit relative to nominal GDP, PAG = price of broad agriculture relative to nontraded goods in nonagriculture, PAGNC = price of noncoffee agriculture relative to nontraded goods in nonagriculture, PTAN1 = price of noncoffee agricultural tradables relative to nontraded goods in nonagriculture, PXAN1 = price of noncoffee agricultural exportables relative to nontraded goods in nonagriculture, PMAG = price of agricultural importables relative to nontraded goods in nonagriculture, FAGFT = price of agricultural food tradables relative to nontraded goods in nonagriculture, and PC1 = price of coffee relative to nontraded goods in nonagriculture.

^a Significant at 98 percent.

^b Significant at 95 percent.

^c Significant at 90 percent.

The estimated equation for the relative price of coffee is equation 14 in Table 12. Coffee is a slightly different case from the previous ones because of the effects of terms of trade and real income. The variables indicated in equation (23) explain more than 90 percent of the variation in coffee prices, but real income is insignificant. Therefore, real interest rate, contemporaneous and lagged terms of trade, and government size are used as independent variables. The contemporaneous effect of terms of trade is positive but the lagged effect is negative. Thus, only one period after the improvement in terms of trade has taken place the Dutch disease effect of the increase in coffee prices begins to emerge in that sector. However, the total effect of increases in the international terms of trade is positive, in contrast with the rest of agriculture, where it is negative. One explanation for the negative sign of the interest rate is that when this rises, the cost of holding stocks increases, so that there is an incentive to release stocks and reduce prices. Another way of looking at this result is that when the interest rate goes up, coffee prices are held down to avoid an excessive accumulation of stocks and an increase in the cost of holding them.

The demand for money was relevant when the determinants of the interest rate in a semiopen economy in the short term were discussed. Therefore, it is important to establish whether the demand for money responds to interest rate changes. To estimate the demand for money, the following estimating equations are used:

$$m^d = \lambda_0 + \lambda_1 Y - \lambda_2 i + u, \quad (24)$$

$$m^d = \lambda_0 + \lambda_1 Y - \lambda_2 i + \lambda_3 m_{t-1}^d + u, \quad (25)$$

and

$$m^d = \lambda_0 + \lambda_1 Y - \lambda_2 i + \lambda_4 TT + u, \quad (26)$$

where

$$\begin{aligned} m^d &= M^d/P = \text{real demand for money,} \\ TT &= \text{terms of trade, and} \\ u &= \text{random term.} \end{aligned}$$

The reason for incorporating the terms of trade is that changes in them are essentially temporary, and since the gain in income is expected to be transitory, part of it will be associated with an increase in the level of savings, which in part is reflected in the accumulation of real cash balances. Therefore, the sign for the terms-of-trade variable is expected to be positive.

All the variables in equations (24) to (26) are in logarithms, except for the nominal interest rate. The results of estimation are reported in Table 13. The estimated coefficients have the expected signs and are highly significant.

Capital Mobility

Next the extent of capital mobility in Colombia is established using two different tests. In equations (18) and (20) it is postulated that the domestic interest rate is determined by the external interest rate, the rate of devaluation, and domestic monetary policy. To estimate this model, the rate of inflation is taken as the variable reflecting the domestic conditions on the monetary policy side. The estimating equations are

$$i = \alpha_0 + \alpha_1 i^* + \alpha_2 \dot{e} + \alpha_3 \pi + u, \quad (27)$$

Table 13—Demand for money

Variable	Equation			
	1	2	3	4
GDP (T)	...	0.62262 ^a (11.0474)	...	...
(T-1)	0.68289 ^a (16.2421)	...	0.4907 ^a (9.4275)	...
Per capita GDP (T-1)	...	...	...	0.2591 ^c (2.4194)
Interest rate (T)	...	-0.00321 ^b (-1.9909)	-0.0269 ^c (-2.307)	-0.0045 ^a (-2.9857)
(T-1)	-0.00593 (-5.1811)	...	...	...
Terms-of-trade (-1)	...	...	0.233 ^a (4.8458)	...
Log per capita real money	...	...	...	0.5487 ^a (3.1237)
Adjusted R ²	0.97	0.96	0.98	0.73
Autocorrelation	...	0.3837	...	...
Durbin-Watson or Durbin-h	2.48	1.45	1.60	0.67 ^d

Notes: All the variables except the interest rate are expressed in logarithms. The dependent variable is the log of the real quantity of money except for equation (4), which is per capita real quantity of money. The period covered is 1968-83 except for equation (2), which is 1969-83.

^a Significant at 99 percent.

^b Significant at 98 percent.

^c Significant at 98 percent.

^d Durbin-h.

and

$$i = \beta_0 + \beta_1 [i^*(1 + \hat{e})] + \beta_2 \pi + u, \quad (28)$$

where

i^* = external rate of interest,
 $\hat{e}$ = rate of devaluation, and
 π = domestic rate of inflation.

The first equation introduces the effects of the foreign interest rate and the rate of devaluation separately, while the second one introduces these effects in one single element, the parity rate $i^*(1 + \hat{e})$. The foreign interest rate is approximated by the London Interbank Offering Rate (LIBOR). The estimated equations are presented in Table 14 and cover the period 1967-83. The results point to a strong link between the domestic and international capital markets and to a large and decisive influence of the parity rate on the domestic interest rate. Thus, despite restrictions on international capital movements, people and businesses move capital in and out of the country. Also, the results support the idea that at least in the short run there is some room for autonomous monetary policy.

Two points about the results presented in Table 14 are worth noting. First, the estimated coefficients of equation 1 in the table indicate that the influence of the parity rate on the domestic interest rate is stronger than the influence of inflation. Second, the estimated coefficients in equation 2 indicate that the influence of the external rate of interest on the domestic interest rate is stronger than that of the rate of devaluation, that is to say, a 1 percent increase in the foreign rate of interest is reflected in the domestic rate of interest by the same amount, while a 1 percentage point increase in the rate of devaluation affects domestic interest rates by half a percentage point.

Table 14—Determinants of the domestic interest rate, 1967-83

Independent Variable	Nominal Interest Rate	
	Equation 1	Equation 2
Constant	-4.30690 (-1.8273)	-5.86710 ^a (-2.4659)
External interest rate	...	1.16138 ^a (4.8140)
Rate of devaluation	...	0.68639 ^a (5.3836)
Parity rate	0.74377 ^a (8.3086)	...
Domestic rate of inflation	0.59370 ^a (5.6967)	0.55500 ^a (5.3013)
Adjusted R ²	0.90	0.91
Durbin-Watson statistic	2.02	2.27

Note: The numbers in parentheses are t-statistics.

^a Significant at 99 percent.

Change in Reserves

The change in reserves is the consequence of changes in the current and capital accounts. From this perspective it can be said that real per capita GDP, the price and quantity of coffee, and the government deficit are important factors in the determination of the current account and that the interest rate differential is the main force behind the capital account. All these factors are also important in the money market. To examine their influence on the accumulation of reserves, the following test is used. The relationship of change in international reserves to high-powered money is used as a dependent variable. On the other hand, the GDP, the terms of trade, the volume of coffee exports, and the differential in the domestic and external interest rates are the independent variables.²⁴ The estimating equation is

$$\delta R/H = \alpha_0 + \alpha_1 \ln PCGDP + \alpha_2 \{i/[i^*(1 + \hat{e})]\} + \alpha_3 \ln P_C + \alpha_4 \ln XC, \quad (29)$$

where

δR = change in international reserves (in pesos),
 H = high-powered money or monetary base, and
 XC = volume of coffee exports.

The results from the estimation of equation (29) are presented in Table 15. From this table, the obvious role played by real income, terms of trade, and volume of coffee exports is clear. However, it is also important to note the role of the interest rate differential in the accumulation of reserves through the capital account, which strengthens the previous findings that there is a strong international mobility of capital in Colombia.

²⁴ This is a modified version of a test suggested by Dornbusch in *Open Economy Macroeconomics*.

Table 15—Determinants of changes in international reserves and the extent of capital mobility

Independent Variable	Change in Reserves Relative to Money Base	
	Equation 1	Equation 2
Constant	5.4307 ^a (2.132)	5.3259 (1.762)
Log real GDP (-1)	-1.1021 ^b (-4.228)	-1.1883 ^b (-2.924)
Interest rate differential	0.069 ^b (3.548)	0.0537 ^b (2.708)
Log coffee price (T-1)	0.719 ^b (2.919)	...
Log terms-of-trade	...	1.2203 ^c (1.8503)
Log volume of coffee exports (T-1)	1.1928 ^b (4.069)	0.9442 ^c (2.5233)
Adjusted R ²	0.66	0.567
Autocorrelation	-0.489 (-1.569)	...
Durbin-Watson statistic	2.29	1.978

Note: The numbers in parentheses are t-statistics.

^a Significant at 95 percent.

^b Significant at 99 percent.

^c Significant at 98 percent.

Conclusions

The profitability and production of noncoffee tradables were subject to substantial negative pressures in the Colombian economy between 1975 and 1983. These pressures arose mainly from the decrease in the real exchange rate (relative price of noncoffee tradables/nontradables) induced by the increase in the terms of trade and later by the growing fiscal expenditure and deficit. Given the increasing mobility of capital in Colombia, fiscal pressures on the real exchange rate are stronger in the long than in the short run due to the effects of additional capital inflows induced by the potential pressure of the deficit on domestic interest rates.

The results, which were presented in some detail in the previous sections on the determinants of relative prices, explain to a large extent the observed decline in agricultural incentives between 1975 and 1983. These regressions do not include a nominal variable; they explicitly leave out the rate of devaluation as a determinant of relative prices in the economy. The rate of devaluation was tried as an explanatory variable to establish whether it would, in fact, affect relative prices, but it turned out to be insignificant.

SUPPLY RESPONSE IN COLOMBIAN AGRICULTURE

This chapter examines the supply response of Colombian agriculture, which is an important issue because a large share of Colombian agriculture is tradable and, hence, the price of agricultural output largely depends on the real exchange rate.

Brief Review of Studies

In the early stages of the import substitution models, it was thought that output in agriculture was not responsive to price incentives. From this point of view, agricultural exports would be exogenous and independent of variables like the real exchange rate or the tariff level. Therefore, a devaluation to correct balance-of-payments disequilibria would essentially be reflected in an acceleration of inflation. Inflation in itself was viewed as a structural phenomenon, arising from insufficient food supplies resulting from a low supply response of agricultural output and a growing demand for food generated by an increase in per capita income. Thus, inflation became a brake on the process of industrialization.

A number of studies on supply response have changed this vision of the world. Moreover, because most of these studies measure area response, total response is underestimated because the responses of labor and capital, especially the latter, are omitted. Thus, when capital and labor responses are considered, the long-run elasticity of supply may be close to or larger than one.²⁵

In the Colombian case a number of studies on agricultural supply response were done in the 1960s and 1970s, and it was found that the supply response was positive and significant in both the short and long runs, both for commercial commodities, such as cotton, sugarcane, coffee, bananas, wheat, sorghum, and soybeans, and traditional ones, such as cassava, beans, and maize.²⁶

The structuralist argument that inflation is caused by insufficient supply response of agricultural products has not been supported by the empirical evidence so far. If the structuralist argument is valid at all, it would be so only in the short run because the response of agricultural products to changes in prices is quite significant in the medium and long runs. Moreover, there is a problem of causation: it is not clear whether agriculture stops industrialization because the supply response is low or whether the industrial protection policy causes the stagnation of agricultural output by reducing incentives to agriculture.

²⁵ See, for example, Domingo Cavallo, "Exchange Rate Overvaluation and Agriculture: The Case of Argentina," a document prepared for a World Development Report, Buenos Aires, September 1985 (mimeographed).

²⁶ For a summary of the results of the major studies, see Roberto Junguito, "Precios Agrícolas, Producción y Asignación de Recursos: La Experiencia Colombiana," *Coyuntura Económica* 10 (April 1980): Tables 3 and 5.

Supply Response for Individual Products

To estimate the supply response for annual or semiannual crops the Nerlove partial adjustment model is used.²⁷ In this model, area in the present period is a function of prices in the current or past period, area lagged one period, and supply shifters. That is,

$$X_t = c_0 \alpha \beta P_{t-1} + (1 - \alpha) X_{t-1} + \sigma Z_t + U_t, \quad (29)$$

where

- X_t = area cropped in time t ,
- P_{t-1} = price of the crop in period $t - 1$,
- Z_t = a supply shifter,
- $\alpha \beta$ = short-term elasticity of supply,
- $\beta = \alpha \beta / [1 - (1 - \alpha)]$ = long-term elasticity of supply, and
- U_t = error term.

The procedure followed to estimate the elasticity of supply for each product will now be described.

Cotton

Cotton is produced in four regions: Costa, Meta, Tolima, and Valle. The cropping season for Costa is the same as for Meta, and the cropping season for Tolima is the same as for Valle. These four regions are usually classified as two regions, Costa-Meta and Interior (Tolima and Valle). Three of the regions, Costa, Meta, and Tolima, produce short-fiber cotton, while Valle has produced long-fiber cotton since 1967. In general, expansion of cotton output has been easier in the Costa-Meta region than in the Interior, where more crops compete for the use of land than in the Costa-Meta region.

Equation (29) is used to estimate the supply response of cotton for each region. The dependent variable is the number of hectares cropped, and the supply shifter is the deviation of yield (tons of raw cotton per hectare) around its trend value, for the region or for the country as a whole. To estimate equation (29), area and prices are expressed in logarithms. For Costa-Meta the price of raw cotton or the price of fiber relative to the price of nonagricultural products (PNA) is used as the price variable, as well as the price of meat relative to fiber. For Valle the price of soybeans relative to the price of cotton fiber is used. Finally, for the country as a whole, the price of raw cotton and the price of fiber relative to the price of nonagricultural products are used. Regressions are run for Costa-Meta, the Interior, Tolima and Valle separately, and the whole country. Results are reported in Table 16 only for Costa-Meta, Valle, and the country as a whole because the regressions run for the Interior and Tolima produced unsatisfactory results.

The statistical results are satisfactory, and the coefficients have the expected signs. For each regression the own price elasticity of supply of cotton is calculated. According to the results presented in Table 16, the short-run response of area in the Costa-Meta region is close to 1.0 while the long-run supply response is about 4.0. For Valle, the

²⁷ See Marc Nerlove, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," *Journal of Farm Economics* 38 (May 1956): 496-509.

Table 16—Logarithmic regressions for estimating the supply response of cotton

Variable	Costa-Meta 1962-84	Valle 1961-83	Total Country 1960-84
Constant	-2.374 (-0.963)	3.312 (3.644)	-1.418 (-0.703)
Area (T-1)	0.778 (6.674)	...	0.739 (5.885)
Trend variability of yield (T-1)	0.907 (2.476)	...	0.768 (2.286)
Relative prices			
Raw cotton/PNA (T-1)	...	...	0.960 (2.801)
Fiber/PNA (T-1)	0.892 (2.236)	...	...
Soybean/fiber (interior) (T-1)	...	-2.691 (-5.116)	...
Soybean/fiber (interior) (T)	...	-1.229 (-2.376)	...
R ²	0.74	0.69	0.71
Durbin-Watson statistic	1.83	1.81	1.75
Durbin-h	0.50	0.46	0.82
Long-term supply elasticity	4.02	...	3.68

Notes: The numbers in parentheses are t-statistics. The dependent variable is total cultivated area in hectares. PNA is the price of nonagricultural products. The regressions for the variability of yield around the trend are as follows: for Costa Meta, $-0.119 + 0.021$ Time; for Valle, $0.463 + 0.011$ Time; and for the total country, $0.036 + 0.017$ Time.

short-run price elasticity is 1.3 for contemporaneous changes in relative prices and 2.7 for changes in relative prices lagged one year. No long-run price elasticity is calculated for Valle because area lagged one year was not significant. For the country as a whole, the short-term elasticity of supply is also close to 1.0, while the long-term elasticity is about 3.7. This high supply response of cotton may be due to the increasing importance of the Costa-Meta region in cotton production in Colombia. In this region, a significant increase in cotton production has taken place through the expansion of area, mainly through clearing of land or the use of land previously devoted to cattle. Although the values of the long-run elasticity of cotton estimated in this report are probably high compared with those estimated for other countries, these values are lower than the corresponding estimates of Palma (14.8) and Fundación para la Educación Superior y el Desarrollo (FEDESARROLLO) (19.4), as reported by Junguito.²⁸

Rice

Rice is produced mainly in four regions: Huila, Tolima, Costa, and Meta, under two different technologies, irrigated and upland. The production of rice increased over time as a result of a successful research program that started in 1957 and the introduction of irrigation in the 1960s. After 1966, a marked increase in yields is observed due to

²⁸ Junguito, "Precios Agrícolas."

adoption of new rice varieties.²⁹ To estimate the supply response of rice, total cultivated area in hectares is taken as the dependent variable. The contemporaneous domestic price of paddy relative to the price of nonagricultural output, area lagged one period, and the ratio of irrigated area to total cropped area in rice—the supply shifter—are the independent variables. Area and price are expressed in logarithms. The regressions cover the 1961-83 period and the results are presented in Table 17.

The estimated short-term price elasticity reported here—between 0.36 and 0.48—is higher than previous estimates. For the short-term supply response Gutiérrez and Hertford estimate an elasticity of 0.213; Montes, Candelo, and Muñoz obtain a value of 0.26; and Hall estimates a value of 0.1.³⁰ The long-run supply elasticity is higher than one, and at least one-third of the total price effect takes place during the first year. Compared with cotton, the estimated value of the long-run elasticity of supply is much lower, 3.7 in cotton and 1.3 in rice, but the total effect of a price change takes place faster in rice. Whereas in rice the total effect of a price change can be felt in less than 6 years, in cotton that effect can take up to 20 years.

Wheat

Wheat is produced in three regions: Boyacá, Cundinamarca, and Nariño. For some time, the production of wheat increased due to the positive effects of a research program started in 1926. Colombia's wheat research program received important assistance from a number of foreign and national organizations. The Rockefeller Foundation was one important source of support until the mid-1960s; other sources were the National Institute of Supplies (Instituto Nacional de Abastecimientos—INA) and some of the farmers' federations, especially the National Federation of Cereal Producers (FENALCE). Despite these efforts in research and the introduction of new varieties in the 1950s and mid-1960s, cultivated area and output have declined sharply. Cultivated area fell steadily from 175,000 to 46,000 hectares between 1953 and 1983. However, yield per hectare increased from 800 to 1,680 kilograms during this period. One of the explanations given for the decrease in acreage planted is the effect of U.S. foreign aid P.L. 480 sales on producer incentives.³¹ Although this interpretation may be correct, it is important to point out that area planted continued falling even after P.L. 480 was phased out.

To estimate the supply response of wheat, both output and area are used as dependent variables. The producer price relative to the price in the nonagricultural sector or to the price of milk is taken as an independent variable. Area, output, and price are expressed in logarithms. Various supply shifters are used: the share of P.L. 480 wheat imports in total wheat production, credit, public research expenditures, and the share

²⁹ An analysis of the profitability of the generation of the new rice technology in Colombia is found in Reed Hertford, et al., "Returns to Agricultural Research Investment in Colombia" in *Resource Allocation and Productivity: National and International Agricultural Research*, ed. Thomas Arnd, D. Dalrymple, and Vernon Ruttan (Minneapolis: University of Minnesota Press, 1977). Also see J. Ardila, *Rentabilidad Social de las Inversiones en Investigación de Arroz en Colombia* (M.S. thesis, ICA-Universidad Nacional, 1973).

³⁰ See N. Gutiérrez and Reed Hertford, *Una Evaluación de la Intervención del Gobierno en el Mercado de Arroz en Colombia*, Centro Internacional de Agricultura Tropical, Folleto Técnico No. 4 (Cali: CIAT, 1974), Table 3; Gabriel Montes, Ricardo Candelo, and Ana Milena Muñoz, "La Economía del Arroz en Colombia," *Revista de Planeación y Desarrollo* (January-April 1980): 115; and Lana Hall, *The Effects of P.L. 480 Wheat in Latin American Countries*, California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, University of California at Berkeley, September 1978, p. 46.

³¹ See Leonard Dudley and Roger J. Sandilands, "The Side Effects of Foreign Aid: The Case of Public Law 480 Wheat in Colombia," *Economic Development and Cultural Change* 23 (January 1975): 325-337.

Table 17—Logarithmic regressions for estimating the supply response of rice

Equation	Period	Constant	Area (T-1)	Rice/PNA	Share of Irrigated Area in Cultivated Area		R ²	Durbin-h	Long-Term Elasticity of Supply
					(percent)	(log of percent)			
1	1961-83	-0.010 (-0.099)	0.667 (5.932)	0.417 (2.179)	0.008 (3.000)	...	0.82	0.83	1.25
2	1961-83	-1.26 (-0.899)	0.744 (6.686)	0.359 (1.779)	...	0.346 (2.496)	0.80	0.76	1.40
3	1961-81	-0.218 (-0.194)	0.673 (5.292)	0.434 (2.061)	0.008 (2.870)	...	0.79	0.65	1.33
4	1961-81	-1.539 (0.966)	0.755 (5.945)	0.387 (1.746)	...	0.375 (2.465)	0.77	0.55	1.58
5	1961-78	-0.097 (0.079)	0.617 (3.864)	0.481 (2.105)	0.003 (2.762)	...	0.69	0.55	1.26

Notes: The numbers in parentheses are t-statistics. The dependent variable is total cultivated area in hectares. PNA is the price of nonagricultural products.

of purchases of wheat by the Institute for Agricultural Marketing (IDEMA) in total wheat production, but these variables turned out to be statistically insignificant. The estimated equations are presented in Table 18.

When the information for the 1950-83 period was used to estimate the supply response of wheat, the statistical results were not satisfactory. Thus, the results reported for two different periods, 1951-72 and 1955-83, are the best ones that could be obtained with the information and specifications used. What comes out of the results is that the price of wheat over the price of nonagriculture, current or lagged one period, is quite significant: the estimated short-term elasticity of area with respect to price varies between 0.38 and 0.45, while the short-term response of output to price changes seems to be higher, around 0.7. The elasticity of wheat output with respect to the relative price of wheat to milk is low and significant but with a lag of five years. The estimated long-term price elasticity varies between 2.2 and 3.3 for area, and it is 1.4 for output. The estimated values are lower than those obtained by Dudley and Sandilands or Junguito, but higher than the value estimated by Palma as reported in Junguito. In any case, these values show that wheat producers respond positively to changes in prices and that their response is as high as the one for rice.

Coffee

Because coffee is a perennial plant, the decisions to plant, uproot, and maintain or increase the productivity of the existing capital stock require a more complex and complete model than the one represented by equation (29). Although some efforts have been made to analyze the supply response of perennials with a modified and more complete framework, this has not been the case for coffee in Colombia.³² There

³² See, for example, Michael Hartley, Marc Nerlove, and R. K. Peters, Jr., *The Supply Response for Rubber in Sri Lanka*, World Bank Staff Working Paper No. 657 (Washington, D.C.: World Bank, 1984). A discussion of the limitations of the Nerlove partial-adjustment model for estimating the supply response in the case of perennials is presented in Marc Nerlove, "The Dynamics of Supply: Retrospect and Prospect," *American Journal of Agricultural Economics* (December 1979): 874-888.

Table 18—Logarithmic regressions for estimating the supply response of wheat

Dependent Variable/ Period	Constant	Area (T-1)	Output (T-1)	Relative Prices			R ²	Durbin-h	Long-Term Elasticity of Supply
				Wheat/PNA		Wheat/ Milk (T-5)			
				(T)	(T-1)				
1. Area (1951-72)	-1.221 (-1.965)	0.859 (7.787)	...	0.456 (2.002)	...	...	0.92	0.24	3.2
2. Area (1951-72)	-1.049 (-1.684)	0.883 (7.820)	...	...	0.383 (1.684)	...	0.92	1.19	3.3
3. Output (1951-72)	-0.504 (-0.524)	...	0.514 (2.776)	...	0.684 (2.346)	...	0.64	0.81	1.4
4. Area (1955-83)	0.386 (1.803)	0.877 (15.119)	...	...	...	0.275 (1.728)	0.96	1.15	2.2

Notes: The numbers in parentheses are t-statistics. PNA is the price of nonagricultural products.

have been estimates of the supply response of coffee in Colombia using a distributed lags analysis framework with modifications, but the complexity introduced does not seem worth the effort if similar results can be obtained using simpler partial-adjustment models.³³ In fact, more recent attempts have used the simplest of partial-adjustment models, based on information on new plantings and replantings with the new, high-yielding *caturra* variety.³⁴ These studies have obtained a higher supply response than earlier ones, for one important reason: the *caturra* variety bears fruit after a shorter time.

Since the purpose of this report is not to make a comprehensive revision and estimation of the supply response of Colombian agriculture, the report builds on the information generated by existing studies to estimate the supply response of coffee using the simple framework of a partial adjustment model. The only data sets found to be useful are Bateman's and Zambrano's.³⁵ The Bateman series covers the period 1936-65, while the Zambrano series covers 1970-83. Junguito's data are not used because the published series covers a shorter period than the one for which he reports results. Since Junguito's results could not be replicated, his information was discarded.³⁶ The series in Bateman has the advantage of being readily available with a relatively large number of observations (30), and they cover the period 1936-65.

The estimates made using the Bateman series are presented in Table 19. All the estimations were based on the simple model of equation (29), and only one equation

³³ Models that estimate the supply response of coffee in Colombia using a modified version of Nerlove's partial-adjustment model include Merrill J. Bateman, *Supply Response in the Colombian Coffee Sector*, Memorandum RM-5780-RC/AID (Santa Monica, Cal.: Rand Corporation, 1969); and Roberto Junguito, "Un Modelo de Respuesta en la Oferta de Café en Colombia," Fundación Para la Educación Superior y el Desarrollo, Bogotá, July 1974 (mimeographed).

³⁴ The *caturra* is a high-yielding variety that was introduced in the coffee-growing areas of Colombia in the early 1970s. Two recent studies that estimate the supply response of coffee using information on area planted with *caturra* varieties are T. Akiyama, "Analysis of Coffee Policy Instruments and Supply Response in Colombia," World Bank, Washington, D.C., June 1985 (mimeographed); and Hernán R. Zambrano, "Tendencias de la Caficultura Colombiana," *Economía Colombiana* (March 1986): 34-46.

³⁵ Bateman, *Supply Response in Colombian Coffee*; and Zambrano, "Tendencias de la Caficultura Colombiana."

³⁶ Junguito, "Un Modelo de Respuesta."

Table 19—Logarithmic regressions for estimating the supply response of coffee

Dependent Variable/ Period	Constant	Price of Coffee			Output of Coffee T-1	Change in Output T-1	Adjusted R ²	Durbin-Watson Statistic	Durbin-h
		T-5	T-6	T-7					
1. Coffee output (1944-65)	2.2597 (3.1578)	0.1684 (2.9911)	...	...	0.5002 (3.3757)	...	0.82	1.91	0.29
2. Coffee output (1940-65)	1.2426 (2.5460)	0.1068 (2.1728)	...	...	0.7138 (7.033)	...	0.85	2.06	-0.17
3. Coffee output (1941-65)	1.7288 (3.111)	...	0.1309 (2.4693)	...	0.6162 (5.221)	...	0.83	2.34	-1.06
4. Coffee output 1942-65	2.2513 (3.2504)	...	...	0.1612 (2.6572)	0.5078 (3.4169)	...	0.81	1.79	0.80
5. Coffee output (1944-65)	4.4718 (32.423)	0.1203 (2.4420)	...	0.2237 (4.7236)	...	0.4465 (3.2066)	0.90	2.37	...

Notes: All coefficients are significant at 99 percent. The numbers in parentheses are t-statistics. T indicates the number of years lagged.

was estimated using the supply shifter, the change in the logarithm of output in the previous period.³⁷ The price variable only became significant when five, six, or seven years' lag was introduced. For some regressions, the simultaneous use of prices lagged five and seven years turned out to be significant, as well as the use of a supply shifter variable (change in output). The supply shifter variable had a positive sign, which is contrary to what is argued by Bateman but in agreement with Junguito.³⁸ From the values reported for the price and output coefficients, short- and long-run price elasticities of 0.25 and 0.40 are derived.

A Model of the Livestock Sector

To study the supply response of the livestock sector, a demographic model is used to generate stocks of male and female animals of different ages.³⁹ This model is presented in Appendix 2. The size of the herd estimated with this demographic model is then used to examine the response of sales (slaughter plus exports) to changes in the prices of beef, crops, and income.

In countries where extensive grazing is the main feeding system, it is to be expected that the short-run elasticity of supply (sales) will be negative, while the long-run elasticity will be positive. This is because animals are a capital good, and an increase in the price of beef increases the present value of animals, thereby inducing ranchers to retain

³⁷ There seems to be some relationship between output in the previous and present periods. For a discussion of this relationship see Bateman, *Supply Response in Colombian Coffee*, ch. 3.

³⁸ Junguito finds in his regressions a positive sign for the coefficient of the variable change in output (see Junguito, "Un Modelo de Respuesta").

³⁹ This section is based (with corrections) on Jorge García García, "The Economics of the Livestock Sector in Colombia: 1957-1977," International Food Policy Research Institute, Washington, D.C., 1980 (mimeographed).

more animals with the purpose of selling them for slaughter at a future date.⁴⁰ Thus, it is expected that the short-run elasticity of supply of female animals will be negative, while that elasticity can be negative or positive for males. The short-run elasticity for male sales may be positive at times because an increase in price increases the present value of female animals proportionally more than that of male animals, and as the size of the herd increases, feed may be insufficient, thus inducing farmers to sell more male animals. As the capital price of female animals includes the price of future births, the short-run elasticity of sales is higher for female than for male animals. In addition, in the short run, when grazing land is limited, entrepreneurs will slaughter more male and fewer female animals. However, if grazing land is available and a larger herd can be fed with the existing feed, both male and female sales will drop in the short run; in the long run, a rise in the price of beef will lead to larger herd sizes and levels of sales.⁴¹

The price of feed also affects sales of male and female animals differently. Because of the longer life span of females, an increase in feed prices reduces the capital value of female animals by more than that of male animals. Therefore, short- and long-run (positive) price elasticities of sales with respect to feed prices are higher for female than for male animals.

Finally, the rate of interest also affects the flow of sales and the size of the herd in the long run. A higher interest rate reduces the capital price of male and female animals, inducing a higher level of sales in the short run and a lower one in the long run, because in the final equilibrium position, the desired stock of animals is lower than the initial one.

Thus, to summarize, let P be the price of beef, P^c the price of feed or of crops that compete with cattle for the use of land, and r the rate of interest. Let MS_t stand for male sales and MH_t stand for the male herd in period t , and FS_t for female sales and FH_t for the female herd in period t . Then

$$MS_t = f(P_t, P_t^c, r, MH_{t-1}), \quad (30)$$

$$FS_t = g(P_t, P_t^c, r, FH_{t-1}), \quad (31)$$

and

$$(\partial MS_t / \partial P_t) < 0, (\partial MS_t / \partial P_t^c) > 0, (\partial MS_t / \partial r) > 0, (\partial MS_t / \partial MH_{t-1}) > 0,$$

and

$$(\partial FS_t / \partial P_t) < 0, (\partial FS_t / \partial P_t^c) > 0, (\partial FS_t / \partial r) > 0, (\partial FS_t / \partial FH_{t-1}) > 0.$$

Letting ϵ_{MP} and ϵ_{MPc} denote the short-run elasticity of supply of male sales with respect to beef and to crop prices, and letting ϵ_{FP} and ϵ_{FPc} denote the same elasticities for females, then

⁴⁰ For an exposition of the theory of investment behavior in the cattle industry, see Raúl Yver, *The Investment Behavior and the Supply Response of the Cattle Industry in Argentina* (Ph.D. dissertation, University of Chicago, 1971), ch. 2; and Lovell S. Jarvis, "Cattle as Capital Goods and Ranchers as Portfolio Managers: An Application to the Argentina Cattle Sector," *Journal of Political Economy* 82 (May/June 1974). See also, Marc Nerlove, D. M. Grether, and J. L. Carvalho, *Analysis of Economic Time Series: A Synthesis* (New York: Academic Press, 1979), ch. 14. An application to Colombia is by Libardo Rivas and Alberto Valdés, "Variaciones en la Existencias de Ganado Un Enfoque Económico," *Revista de Planeación y Desarrollo* (May/August 1978). For a simpler framework also applied to Colombia, see Reed Hertford and Gustavo Norez, *Caracterización del Sector Ganadero de Colombia: 1953-1975* (Cali, Colombia: Centro Internacional de Agricultura Tropical, 1982).

⁴¹ But, when intensive feeding systems are in operation there is no reason to expect a negative short-run supply elasticity of sales.

and

$$\epsilon_{MP} < \epsilon_{FP},$$

$$\epsilon_{MPc} < \epsilon_{FPc}.$$

Also, if ϵ_{MH} and ϵ_{FH} denote the elasticity of supply of male and female sales with respect to the male and female herd, it should be expected that

$$\epsilon_{MH} = \epsilon_{FH} = 1.$$

For testing the above hypotheses, the variables used are number of animals sold and price per animal.⁴²

To estimate the short-run supply response of male, female, and total sales to price changes the following general-form estimating equations were used:

$$\ln MS_t = \alpha_0 + \beta_0 \ln P_{t-J} + \gamma_0 \ln P_{t-k}^c + \lambda_0 \ln MH_{t-1}, \quad (32)$$

$J = 0, 3, 4$, and $k = 0, 1$
for male sales;

$$\ln FS_t = \alpha_1 + \beta_1 \ln P_{t-J} + \gamma_1 \ln P_{t-k}^c + \lambda_1 \ln FH_{t-1}, \quad (33)$$

$J = 0, 3, 4$, and $k = 0, 1$
for female sales; and

$$\ln TS_t = \alpha_2 + \beta_2 \ln P_{t-J} + \gamma_2 \ln P_{t-k}^c + \lambda_2 \ln TH_{t-1}, \quad (34)$$

$j = 0, 3, 4$, and $k = 0, 1$
for total sales

The price variable is the price of male animals sold in the Medellín stockyards, expressed in constant prices of 1952, with the wholesale price index used as the deflator. The price of cotton, current and lagged, is used as the representative crop price. The results of the estimations are presented in Table 20.

Regression equations (1-4), (7-10), and (13) in Table 20 express sales as a function of the current price of beef and the stock of animals at the end of the previous period. The estimated coefficients have the expected signs and are significant at 99 percent. As expected, the absolute value of the price elasticity of supply for current price changes is higher for female sales (between -0.45 and -1.16) than for male sales (between -0.2 and -0.3), and the elasticity of sales with respect to herd is not significantly different from one.

Regression equations (3), (4), (9), and (10) in Table 20 present estimates for the *male and female sales equations incorporating the price of crops as an additional

⁴² When looking at the supply response of the livestock sector the interest is in the supply of beef rather than in the number of cattle; therefore, the dependent variable should be expressed as weight and the independent variable as price per unit of weight. However, this information is not available for most of the period.

Table 20—Short-run supply elasticity of male, female, and total sales of cattle, 1945-75

Dependent Variable	Constant	P _t	P _{t-3}	P _{t-4}	P _t ^c	P _{t-1} ^c	MH _{t-1}	FH _{t-1}	TH _{t-1}	Number of Observations	R ²	p	Durbin-Watson Statistic
1. MS	-0.8177 (0.645)	-0.2732 (0.083)	...	...	...	...	1.1088 (0.078)	...	...	30	0.973	0.554 (0.15)	1.89
2. MS	-1.345 (0.82)	-0.2935 (0.097)	...	...	...	...	1.1837 (0.090)	...	...	25	0.963	0.4700 (0.17)	1.89
3. MS	0.395 (1.31)	-0.2915 (0.095)	...	...	-0.1902 (0.088)	1.1209	...	...	...	24	0.960	0.5740 (0.16)	1.81
4. MS	-1.7849 (1.34)	-0.3244 (0.102)	...	...	...	0.1508 (0.113)	1.1393 (0.118)	...	...	24	0.960	0.5700 (0.16)	1.81
5. MS	-3.398 (0.861)	...	0.3311 (0.109)	...	...	...	0.9719 (0.10)	...	...	22	0.945	0.3300 (0.20)	1.72
6. MS	-3.17 (1.09)	...	...	0.2877 (0.102)	...	...	0.9779 (0.126)	...	...	22	0.959	0.4800 (0.18)	1.35
7. FS	0.6127 (2.04)	-0.8941 (0.245)	...	...	...	...	...	1.2667 (0.265)	...	30	0.75	0.51 (0.15)	1.69
8. FS	-0.999 (2.56)	-1.1634 (0.279)	...	...	...	...	...	1.6267 (0.318)	...	25	0.75	0.43 (0.18)	1.81
9. FS	-0.6533 (3.57)	-1.1396 (0.307)	...	...	-0.094 (0.27)	...	...	1.6423 (0.35)	...	24	0.73	0.44 (0.17)	1.75
10. FS	-0.9015 (3.57)	-1.1473 (0.307)	...	...	...	-0.0611 (0.321)	...	1.6513 (0.352)	...	24	0.73	0.42 (0.18)	1.75
11. FS	-9.337 (2.34)	...	1.1484 (0.240)	...	...	...	...	0.9623 (0.253)	...	22	0.73	0.16 (0.21)	1.75
12. FS	-7.69 (2.07)	...	...	1.044 (0.249)	...	...	...	0.8548 (0.252)	...	22	0.71	-0.02 (0.21)	1.79
13. TS	-1.945 (2.01)	-0.6442 (0.141)	...	...	...	...	...	...	1.4064 (0.22)	25	0.92	0.62 (0.15)	1.73
14. TS	-6.5286 (1.56)	...	0.6942 (0.148)	...	...	...	...	...	1.016 (0.162)	22	0.90	0.32 (0.20)	1.67

Notes: The numbers in parentheses are standard errors. P is price, MH is male herd, FH is female herd, TH is total herd, MS is sales of male cattle, FS is sales of female cattle, and TS is total sales.

explanatory variable. The coefficients for the own price and herd variables have the expected signs and are highly significant, and the estimated short-run elasticity for female sales is higher than for male sales. However, the estimated coefficients for the prices of crops are not significant.

When the expansion of crop and beef output comes through an expansion in cultivated area, it is possible that crop prices do not have a strong influence on beef production. This seems to have been the case in Colombia.⁴³ Moreover, since the estimated price coefficient for sales has a negative sign, this might indicate that in the short run an increase in prices leads to a retention (withholding) of animals from sales, thus supporting the idea that during the period under consideration land was not a limiting factor.⁴⁴

Regression equations (5), (6), (11), and (14) show the response of male and female sales to changes in prices three and four years back. The results show a positive price elasticity and indicate that after some time has elapsed prices and sales are positively associated. This finding suggests that present sales are the result of price changes in several periods rather than in one, thereby indicating that the estimation of the sales equation should incorporate several past price changes.

Since the economic horizon of cattle growing is longer than one year, it is reasonable to incorporate explicitly the effect of past prices on the present level of sales. Past prices affect the desired stock of animals, and changes in the stock will come through changes in sales and births. For example, an increase in the price of beef increases the stock of animals desired. To reach this desired position, sales have to fall or births have to increase, so that the actual and desired additions to the stock are equal until long-run equilibrium is achieved.

To estimate the supply response of male and female sales in the short and long runs, past price changes are incorporated using the polynomial distributed lag model. To estimate the distributed lag equation, a third-degree polynomial with lags of six and eight periods for the price variable is used. The general form of the model is

$$\ln MS_t = C + \sum_{i=0}^J \alpha_i \ln P_{t-i} + \beta_M \ln MH_{t-1}, \quad (35)$$

$$\ln FS_t = C + \sum_{i=0}^J \gamma_i \ln P_{t-i} + \gamma_H \ln FH_{t-1}, \text{ and} \quad (36)$$

$$\ln TS_t = C + \sum_{i=0}^J \lambda_i \ln P_{t-i} + \lambda_H \ln MH_{t-1}, \quad (37)$$

where $J = 6, 8$, and C is a constant. The α_i and γ_i coefficients measure the effect of a change in price in period $t - i$ on male and female sales in period t , and the β_M and γ_H coefficients measure the influence of the male herd on male slaughter and the female herd on female slaughter in period t . The equations are estimated using ordinary

⁴³ See Ramiro Orozco, *Sources of Agricultural Production and Productivity in Colombian Agriculture* (Ph.D. dissertation, Oklahoma State University, 1977).

⁴⁴ These arguments should not be interpreted as saying that crop prices are not important. In fact, in the long run changes in crop prices will affect the size and location of this activity. Thus, the Eastern Plains region, where land is more abundant, has gained in importance as a beef producer.

least squares and unrestricted coefficients. The results are reported in Table 21.⁴⁵ Statistically the results are good and conform to the hypothesis about expected signs and values for the estimated coefficients.

An increase in the contemporaneous price of beef strongly reduces the sale of females, while it has a negligible effect on the sale of males. Moreover, total sales fall when the contemporaneous price of cattle rises. These results support the hypothesis that the price elasticity of female sales is higher (in absolute value) than the price elasticity of males. The strongest effect on male and female sales of a price change is felt three years after the change takes place. The effect of a price change extends to six years for females and five years for males. Moreover, the average time (estimated mean lag) that it takes for a price change to work out its effects on sales is around 3.0 years for males and between 4.5 and 5.5 years for females as evidenced by the size of the estimated mean lag. For total sales the estimated mean lag fluctuates between 3.4 and 3.9 years.

The "long-run" supply elasticity of male and female sales is the sum of all the estimated price coefficients. According to these estimates, the supply elasticity of female sales is large and higher than that for male sales, and the estimated long-run elasticity of supply of total sales varies between 1.38 and 1.45. In summary, these estimates strongly support the hypothesis that cattle sales respond positively to price changes in the long run, despite negative short-run responses.

Supply Response of Aggregate Agricultural Output

The issue of aggregate supply response in Colombian agriculture has not been dealt with in Colombian literature, except for efforts by García to estimate the supply response of food for the period 1950-76.⁴⁶ A very simple framework is used here to estimate the aggregate supply response of agriculture in Colombia for the period 1950-80.

Aggregate supply response in agriculture is a complex subject, and to deal adequately with it requires a considerable amount of information and modeling.⁴⁷ Thus, one would like to capture all the interactions between product and factor markets as well as the role of technical change in that response. Changes in relative output prices trigger changes in factor prices, as well as movement of factors within agriculture and between agriculture and the rest of the economy. Capital accumulation depends on expected returns to capital, which in turn depend on relative prices. In addition, the adoption of new technologies is also a function, among other things, of relative prices and the rate of capital accumulation.⁴⁸ To model this type of interaction between product and factor markets is not possible at the present stage, because the information available

⁴⁵ Equations (35), (36), and (37) were also estimated with ordinary least squares and far-end constraints on the coefficients, and the results were similar to the ones presented here.

⁴⁶ See Jorge García García, *The Effects of Exchange Rate and Commercial Policies on Agricultural Incentives in Colombia: 1953-1978*, Research Report 24 (Washington, D.C.: International Food Policy Research Institute, 1981), Appendix 2.

⁴⁷ For a recent survey of the issue of aggregate supply response in agriculture and the problems involved in analyzing agricultural supply in a general equilibrium comparative dynamics framework, see Yair Mundlak, *The Aggregate Agricultural Supply*, Working Paper No. 8511 (Rehovot, Israel: Center for Agricultural Economic Research, 1985). An analysis of these interrelations for Argentina is found in Cavallo and Mundlak, *Agriculture and Economic Growth in an Open Economy: The Case of Argentina*.

⁴⁸ See Mundlak, *Aggregate Agricultural Supply*, pp. 44-58; and Yair Mundlak, *Capital Accumulation, the Choice of Technique and Agricultural Output*, Working Paper No. 8504 (Rehovot, Israel: Center for Agricultural Economic Research, October 1984).

Table 21—Short- and long-run responses of male, female, and total cattle sales, estimated using polynomial distributed lags, 1954-75

Coefficient	Regression and Dependent Variable					
	(1) MS	(2) MS	(3) FS	(4) FS	(5) TS	(6) TS
Constant	-2.805 (1.41)	-2.9374 (1.29)	-9.7687 (2.19)	-9.957 (2.76)	-7.578 (1.20)	-7.8449 (1.22)
P_t	-0.0555 (0.11)	-0.0355 (0.07)	-0.5764 (0.32)	-0.52 (0.22)	-0.2002 (0.17)	-0.2031 (0.11)
P_{t-1}	0.0623 (0.06)	0.0783 (0.07)	0.4601 (0.09)	0.459 (0.14)	0.1329 (0.07)	0.1711 (0.09)
P_{t-2}	0.1255 (0.06)	0.1398 (0.07)	0.4601 (0.09)	0.459 (0.14)	0.328 (0.06)	0.3671 (0.07)
P_{t-3}	0.1464 (0.07)	0.1587 (0.06)	0.5564 (0.08)	0.5816 (0.11)	0.4047 (0.06)	0.4223 (0.06)
P_{t-4}	0.1371 (0.07)	0.1449 (0.05)	0.5153 (0.12)	0.5408 (0.08)	0.3829 (0.07)	0.3741 (0.05)
P_{t-5}	0.1101 (0.05)	0.1083 (0.04)	0.395 (0.10)	0.3972 (0.09)	0.2822 (0.06)	0.2598 (0.05)
P_{t-6}	0.0774 (0.07)	0.0586 (0.03)	0.2934 (0.28)	0.2116 (0.12)	0.1225 (0.14)	0.1167 (0.06)
P_{t-7}	...	0.0057 (0.03)	...	0.0449 (0.15)	...	-0.0177 (0.07)
P_{t-8}	...	-0.0404 (0.05)	...	-0.0422 (0.21)	...	-0.1064 (0.10)
$FH4_{t-1}$	...	...	0.6336 (0.28)	0.6387 (0.32)	...	...
$MH3_{t-1}$	0.7709 (0.12)	0.7753 (0.11)	...	...	...	...
TH_{t-1}	...	...	...	...	0.6361 (0.18)	0.7074 (1.22)
Sum of price coefficients	0.6033 (0.37)	0.6183 (0.34)	1.7622 (0.48)	0.7848 (0.46)	1.4531 (0.40)	1.3839 (0.37)
R^2	0.98	0.98	0.87	0.84	0.95	0.95
Mean lag	3.8388 (0.82)	3.2721 (1.17)	4.8371 (0.95)	4.5775 (1.65)	3.9095 (0.67)	3.3908 (1.08)
Durbin-Watson statistic	1.41	1.47	1.92	1.90	1.57	1.69
Number of observations	22	22	22	22	22	22

Notes: The variables are expressed in logarithms. The numbers in parentheses are standard errors. P_{t-1} is price lagged by i years. FH is female herd, MH is male herd, and TH is total herd. MS is male sales, FS is female sales, and TS is total sales. Ordinary least squares and unrestricted coefficients are used to estimate the equations.

is inadequate and because it is beyond the scope of this report. Therefore, the results reported here using a simpler framework can only be considered preliminary.

Factors other than price of output have been incorporated as explanatory variables of agricultural supply.⁴⁰ The attempt at estimating supply response in Colombian agri-

⁴⁰ Information to incorporate these other factors is taken from Victor Elías, *Government Expenditures on Agriculture and Agricultural Growth in Latin America*, Research Report 50 (Washington, D.C.: International Food Policy Research Institute, 1985).

culture in this section is done in terms of gross value of output and real value added. The estimating period covers the years 1950-80, using data from the national accounts of Banco de la República.⁵⁰

The estimating equation takes the following general form:

$$\ln O = c + \alpha \ln P + \beta \ln K + \sigma \ln F + \delta \ln T + \gamma \ln L + \theta \text{PCI} + \mu \text{PI} + u, \quad (38)$$

where

- $\ln$ = natural logarithm of the variable,
- O = real gross output or real value added (in 1975 pesos),
- P = price of agriculture (gross output or value added) relative to price of nonagriculture (value added),
- K = real physical capital stock in agriculture (in 1958 pesos),
- F = index of fertilizer use,
- T = harvested land,
- L = labor employed in agriculture,
- PCI = per capita income or comprehensive capital, and
- PI = public input (in 1960 pesos).

A variable that should have been included but is not, due to lack of information, is the price of agricultural inputs. The data for all the variables in equation (38) except output, per capita income, prices, and labor are taken from a study by Victor Elías.⁵¹

Initially, the variables listed in equation (38) were used simultaneously. The public input variable was not significant and the coefficient for harvested land was negative but not significant. The negative sign for the land coefficient is probably the result of having an inadequate measure of this variable. Harvested land only refers to land used in crops, thereby omitting land used in livestock production, an activity that composes one-third of agricultural output. The capital stock in livestock was tried as another explanatory variable, but its significance varied greatly between regressions, and for this reason it was left out.⁵²

⁵⁰ Another set of statistics on agricultural output, beginning with 1965, is available from DANE, but this set is not used because it is not totally compatible with that from Banco de la República, *Cuentas Nacionales*.

⁵¹ Elías' information is used as it is presented; no attempt is made to convert his series to 1975 prices, since neither the deflators nor the nominal values for the series are reported. The difference in the value of the deflators would be reflected in the value of the constant (Elías, *Government Expenditures on Agriculture*).

⁵² Information on herd size is taken from a study by Rivas, but his estimates may present problems due to the treatment given to illegal export or slaughter (extraction). Rivas assumes that illegal or nonregistered extraction is a constant 10 percent of legal extraction. This is not correct because an important component of illegal extraction is smuggled to Venezuela and therefore depends on price differentials between the two countries. Differentials have not remained constant over time. See Libardo Rivas, "Evolución del Inventario Vacuno de Colombia y su Interacción con los Precios 1951-1980," *Revista de Planeación y Desarrollo* 14 (September-December 1982): 162-184.

The variables that produce consistent results over the various regressions are prices, capital stock, fertilizer, employment, and GDP per capita, the latter taken as a measure of comprehensive capital.⁵³ Fertilizer is taken as an explanatory variable because it may have been an important constraint in the growth of agricultural output, considering that this input was not readily available to farmers in the desired quantities and qualities due to import restrictions. This variable turns out to be highly significant in explaining supply response. Both fertilizer and capital accumulation capture part of the effect of changes in agricultural prices, because an increase or decrease in those prices tends to make the use of fertilizer or the return to capital more or less profitable. This may bias the estimated coefficient for agricultural prices downward.

The results from estimation of the aggregate supply response are presented in Table 22. When the estimated price coefficient is lagged two periods, it varies between 0.10 and 0.20 when real value added is the dependent variable, and it rises to 0.25 when real gross value of output is the dependent one. According to these results the response of agricultural output to changes in prices is not high and takes more than one period to occur. It should be kept in mind when interpreting these results that two-thirds of agricultural output (one-third each) is generated by livestock and coffee, which take more than one year to respond to changes in prices compared with annual crops. In addition, because a full interrelationship between factors and product markets is not considered here, the estimates presented are short-run price elasticities, rather than medium- or long-run ones. To correctly evaluate the role of price, the response of the various inputs to price variations should also be evaluated. This, however, could not be done because information on input prices is not available.

One final note on this issue of aggregate supply response. An attempt to estimate the supply response of agricultural output was done using the partial adjustment model utilized in the estimation of the individual commodities. This effort was only successful for the estimation of the supply of food and then only where the price of food was divided by the implicit GDP deflator. The results of this attempt are also reported in Table 22. The estimated short-term elasticity of supply of food is 0.4, but the long-term elasticity of food supply cannot be calculated, as the coefficient for lagged food output is larger than one.

⁵³ See H. Binswanger, et al., *Estimation of Aggregate Agricultural Supply Response*, ARU Report No. 48, Agricultural and Rural Development Department (Washington, D.C.: World Bank, 1985), pp. 28-29.

Table 22—Estimation of aggregate supply response in agriculture

Dependent Variable/ Period	Constant	Price of Food T-1	Price of Agriculture T-2	Capital Stock T-1	Fertilizer T-1	Employment T	Per Capita GDP Index T	Food T-1	Adjusted R ²	Auto-correlation	Durbin-Watson Statistic
Real value added 1953-80	-2.66483 ^a (-17.00)	...	0.13412 ^b (2.2337)	0.71852 ^a (34.624)	0.14186 ^a (15.424)	...	...	...	0.9949	-0.13266 (-0.6223)	2.0064
Real value added 1953-80	-11.20722 ^a (-3.927)	...	0.11134 ^b (1.9954)	0.5814 ^a (11.378)	0.05858 ^b (2.0629)	...	...	...	0.9963	...	1.7616
Real value added 1953-80	-2.38859 ^a (-12.40)	...	0.17087 ^a (2.6331)	0.36321 ^a (2.6704)	0.12651 ^a (11.552)	...	0.65073 ^a (2.7020)	...	0.9959	0.09284 (0.4306)	...
Real value added 1952-80	-9.24207 ^a (-3.372)	...	0.12582 ^b (2.4573)	0.42245 ^a (4.4610)	0.06587 ^a (2.4918)	1.01633 ^a (2.4808)	0.34623 ^b (1.9242)	...	0.9969	...	1.6840
Real value added 1952-80	-2.4533 (-15.1826)	...	0.1541 ^a (2.8013)	0.4495 (4.3363)	0.1276 ^a (13.0699)	...	0.4961 ^a (2.6564)	...	0.9962	...	1.9214
Real gross output 1952-80	-4.1219 ^a (-9.362)	...	0.22979 ^a (3.2632)	0.76826 ^a (30.224)	0.15103 ^a (15.625)	...	...	...	0.9949	...	1.9094
Real gross output 1952-80	-9.9729 ^a (-3.077)	...	0.2136 ^a (3.1432)	0.6615 ^a (11.3540)	0.0931 ^a (2.8100)	0.896 ^c (1.8206)	...	...	0.9953	...	1.7825
Real gross output of food 1951-80	-2.2324 ^a (-2.737)	0.41297 ^a (2.5979)	...	...	...	...	...	1.03453 ^a (56.8365)	0.9918	...	2.1659

Notes: Where real value added is the dependent variable, the relative price is the price of value added in agriculture over the price of value added in nonagriculture. Where real gross value of output is the dependent variable, the relative price for regressions is the price of gross value of output over the price of value added in nonagriculture. Where real gross value of food output is the dependent variable, the relative price is the price of the gross value of food output over the GDP deflator.

^a Significant at 99 percent.

^b Significant at 97 percent.

^c Significant at 95 percent.

INCOME DISTRIBUTION AND REAL WAGES IN AGRICULTURE

The issue of income distribution is a topic that has attracted substantial attention among students of Colombian economic development. Research on this topic has concentrated on the personal and regional inequality of income, both urban and rural, and in the country as a whole.⁵⁴

This chapter breaks with that tradition in the sense that it examines, first, the effects of changes in the price of coffee on the functional distribution of income between labor and nonlabor factors of production in different sectors of the economy (coffee, noncoffee tradables, and nontradables), and, second, the factors that affect real wages in the agricultural sector. The framework used for the analysis of the effect of terms-of-trade changes on the functional distribution of income is the one developed by Corden and Neary.⁵⁵ For the convenience of the reader, points in that paper relevant for the analysis here are summarized in the first part of this chapter. The factors that determine behavior of real wages in agriculture are examined with the help of a simple framework of supply and demand for labor, which incorporates elements of the Todaro model.⁵⁶ The main implications from each model are tested using data for 1970-82 for the effect of terms-of-trade changes on the functional distribution of income and 1967-83 for the determinants of rural wages.

Functional Distribution of Income

Theoretical Framework

The framework adopted is the same one used in Chapter 4, that is, a small, open economy, which produces two traded goods, coffee and noncoffee, at exogenously given world prices, and one nontraded good. Prices are assumed to be flexible to restore equilibrium in supply and demand in the nontraded goods market, and income is assumed to equal expenditure, thereby satisfying the basic conditions for general equilib-

⁵⁴ See especially R. Albert Berry and Miguel Urrutia, *Income Distribution in Colombia* (New Haven, Conn.: Yale University Press, 1976); R. Albert Berry, "Land Distribution, Income Distribution and the Productive Efficiency of Colombian Agriculture," *Food Research Institute Studies in Agricultural Economics, Trade and Development* 12 (No. 3, 1973); Rafael Prieto, *Estructura del Gasto y Distribución del Ingreso Familiar en Cuatro Ciudades Colombianas: 1967-1968* (Bogotá: Centro de Estudios sobre Desarrollo Económico, Universidad de los Andes, 1971); Gary S. Fields and T. Paul Schultz, "Regional Inequality and other Sources of Income Variation in Colombia," *Economic Development and Cultural Change* (April 1980): 447-467; and Miguel Urrutia, *Winners and Losers in Colombia's Economic Growth of the 1970s* (Oxford: Oxford University Press, 1985).

⁵⁵ Corden and Neary, "Booming Sector and Deindustrialization." The authors have also benefited from a paper by Harold E. Banguero, "Evaluating the Impact of a Coffee Boom on Income Distribution: An Examination with Colombian Data," 1986 (mimeographed).

⁵⁶ Michael P. Todaro, "A Model of Labor Migration and Urban Unemployment in the Less Developed Countries," *American Economic Review* 60 (March 1969); and John R. Harris and Michael Todaro, "Migration, Unemployment, and Development: A Two Sector Analysis," *American Economic Review* (March 1970): 126-142.

rium in the system. The framework presented in this section summarizes briefly the relevant points of the Corden and Neary paper, which is concerned with the issue of the functional distribution of income.

Because a large share of agricultural output is tradable, one of the main concerns of the analysis is to establish what happens to the profitability and income of factors of production in the noncoffee tradables sector when there is a large change in the price of coffee.

The analysis proceeds by considering different degrees of intersectoral factor mobility. To facilitate the discussion, the analysis starts with a case in which only one factor (labor) is mobile between sectors and the others are sector-specific.⁵⁷ The analysis is later expanded to a situation in which more than one factor is mobile. The actual extent of factor mobility is not known in advance, and it can only be presumed from the empirical results presented in the second section of this chapter.

Following Corden and Neary, a distinction is made between the resource movement effect and the spending effect of the boom on income distribution. The resource movement effect occurs when the boom raises the marginal products of the mobile factors in the coffee sector and draws resources out of other sectors, inducing the rest of the economy to make adjustments. One of these adjustments is the appreciation of the real exchange rate, that is, a rise in the relative price of nontraded to traded goods. The spending effect results from a higher real income generated by the boom, which leads to additional spending on nontraded goods, which in turn raises their prices (a real appreciation), leading to further adjustments in the economy. If only one factor is mobile between sectors, the resource movement and spending effects lead to a reduction in the relative size of the sector producing noncoffee tradables.

The results on income distribution depend on several important assumptions. The first has to do with the mobility or specificity of resources between coffee and other sectors of the economy. In the short run, there is likely to be some movement of labor from one sector to another, but capital (land, investment in coffee trees, physical capital, and so forth) is only mobile in the medium and long runs.⁵⁸ The second assumption deals with the distribution of coffee earnings and the marginal propensities to consume nontraded goods. The final important element is the assumption of capital-intensity for the different sectors. An analysis of the two cases relevant to the discussion of the effects of terms-of-trade changes on the functional distribution of income is presented in the next two sections.

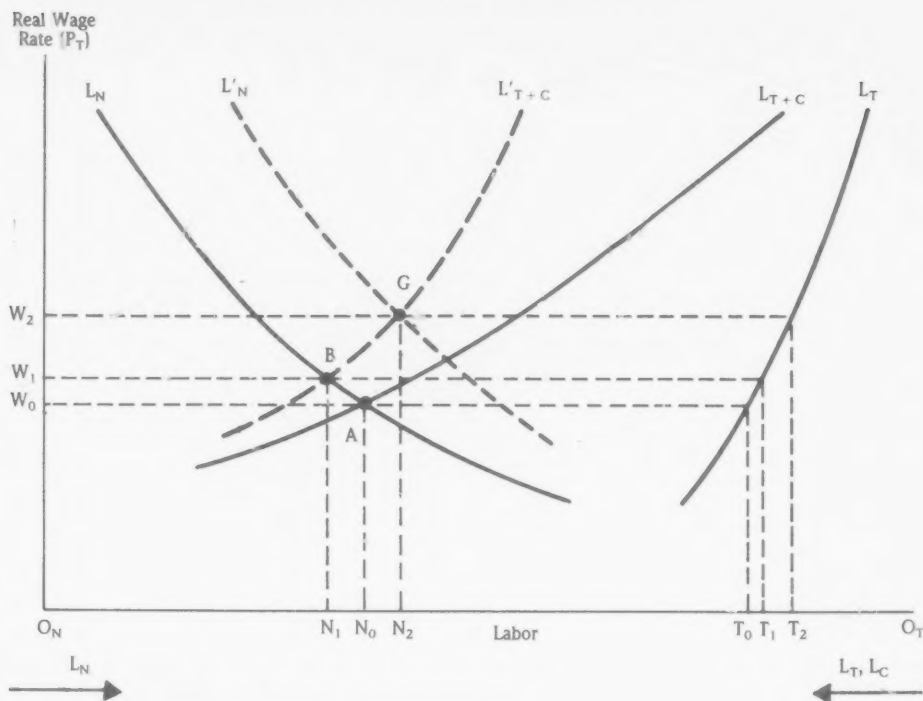
Effects of a Coffee Boom When Only Labor Is Mobile

The effects of a boom on labor and commodity markets are analyzed with the help of Figures 4 and 5. The price of the noncoffee tradable commodity is selected as the numeraire. The wage rate expressed in terms of noncoffee tradables is measured on the vertical axis of Figure 4, while total labor supply is measured by $O_N O_T$ on the horizontal axis. Labor input into nontraded commodities (N) is measured by the distance from O_N , while distances from O_T measure labor input into traded commodities (T), such as coffee and other tradables. The demand for labor is assumed to be a decreasing

⁵⁷ For this kind of model, see R. W. Jones, "A Three Factor Model in Theory, Trade and History," in *Trade, Balance of Payments and Growth: Essays in Honor of C. P. Kindleberger*, ed. J. N. Bhagwati et al. (Amsterdam: North Holland, 1971); R. H. Snape, "Effects of Mineral Development on the Economy," *Australian Journal of Agricultural Economics* 21 (December 1977): 147-156; and Corden and Neary, "Booming Sector and Deindustrialization."

⁵⁸ The empirical results presented in this report strongly support this assumption.

Figure 4—Effect of a coffee boom on the labor market



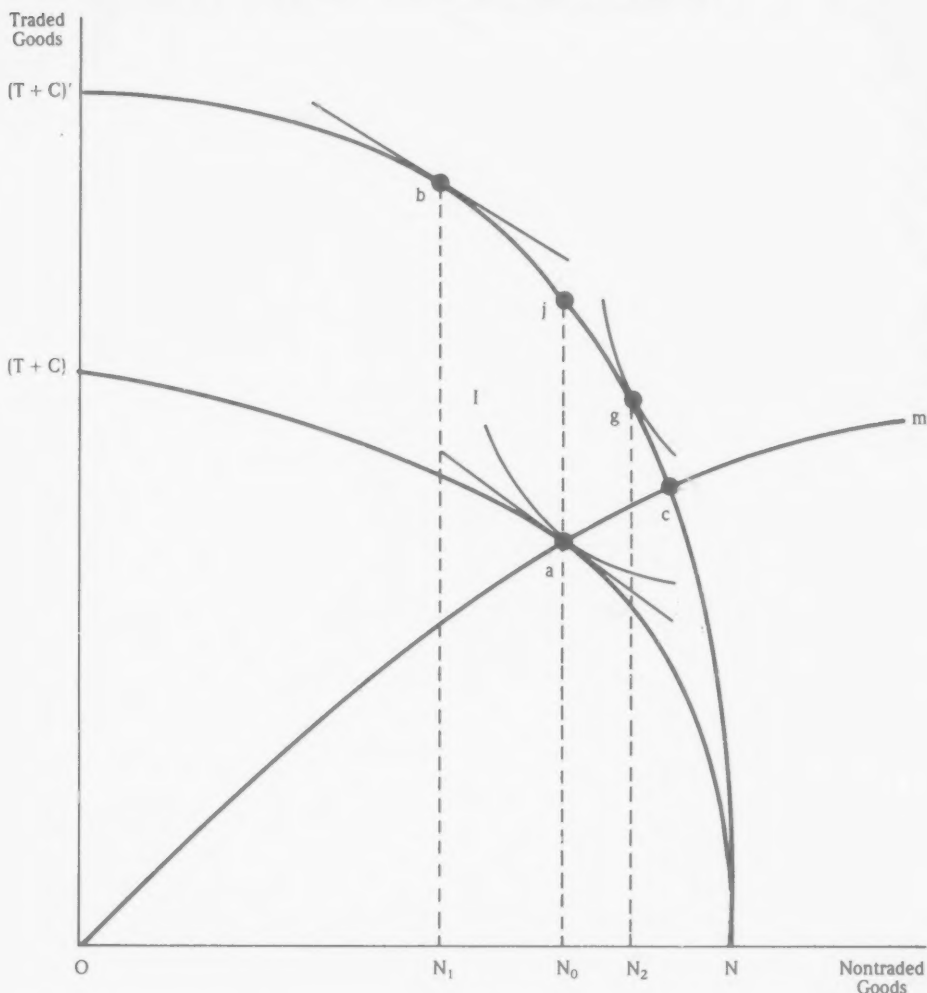
Notes: O_N = Total labor supply used in the nontraded goods sector.
 O_T = Total labor supply used in the traded goods sector.

function of the wage rate relative to the price of each sector's output. Therefore, L_T is the labor demand schedule for noncoffee tradables, and by adding the demand for labor for coffee to it, the demand for labor for tradables is obtained. It is shown as L_{T+C} in Figure 4. Similarly, L_N is the nontraded sector's initial labor demand. Initial equilibrium in the labor market is at A, where L_N intersects L_{T+C} ; therefore, the initial wage rate is W_0 .

It is necessary, however, to determine the initial price of nontraded commodities to complete the general equilibrium model because the location of the L_N schedule depends on this price. Figure 5 shows how it is determined. Traded goods—coffee plus other tradables—are plotted on the vertical axis and nontraded goods on the horizontal one. The initial production possibility curve is given by $(T+C)N$, and initial equilibrium is at point a, when the production possibility curve is tangent to the indifference curve I. The initial price of nontraded goods or the initial exchange rate for traded goods is thus given by the slope of the common tangent at point a.

Continuing the distinction made before, the resource movement and the spending effects of the boom are looked at separately. In the case of resource movements a two-stage analysis is conducted. First, the real exchange rate (relative price of nontradables) is held constant; then it is allowed to change to restore equilibrium. Therefore, in the first stage the L_N curve in Figure 4 and the price ratio in Figure 5 are unchanged.

Figure 5—Effect of a coffee boom on the commodity market



When a sudden rise in the international price of coffee causes the L_{T+C} curve to shift upward to L'_{T+C} , the wage rate rises to W_1 . At the constant real exchange rate, in the absence of unemployment, this increase in wages induces labor to shift from nontraded goods to coffee. The boom raises maximum output of traded goods from $(T+C)N$ to $(T+C)'N$ in Figure 5. The effect of resource movement on output at a constant real exchange rate is given by the leftward displacement of the production point from a to b in Figure 5. In this way, the movement of labor out of nontradable goods causes the output in this sector to fall.

Assuming, for the moment, that the income elasticity of demand for nontraded goods is zero, the resource movement effect at the initial real exchange rate leads to excess demand for nontraded goods, which means that there must be a real appreciation

of the exchange rate in order to restore equilibrium, with equilibrium taking place at some point between *b* and *j* on the $(T + C)'N$ curve.

In order to analyze the spending effect, the resource movement effect is controlled by assuming that the coffee sector does not use any labor. Therefore, at the initial real exchange rate the boom has no effect on labor demand curves L_N and L_{T+C} in Figure 4. However, the boom shifts the production possibility curve vertically upwards, point *b* now lying above point *a* in Figure 5. If the demand for nontraded goods rises with income, the demand at the initial exchange rate moves along an income-consumption curve represented by O_m in Figure 5, intersecting the production possibility curve $(T + C)'N$ at point *c*. Again, there is an excess demand for nontraded goods at the original real exchange rate, indicating that a real appreciation must occur, but this time output of nontraded goods rises because the new equilibrium must be somewhere between *j* and *c*.

When the resource movement and the spending effect are combined, it can be seen that both contribute to a real appreciation of the real exchange rate. However, the resource movement effect tends to lower output of nontraded goods, whereas the spending effect tends to raise it. Figure 5 represents the case where the spending effect is stronger, so point *g* lies to the right of point *j*. This ambiguity does not occur with output of noncoffee tradables.

Returning to Figure 4, the curve representing the demand for labor for the nontraded sector shifts upward to $L'N$ because of the increase in the price of nontraded goods, and the final equilibrium is reached at point *G*. As a result, the wage rate rises to W_2 , and employment in the noncoffee tradable sector falls from $O_T T_1$ to $O_T T_2$. Thus, because of the movement of resources the coffee boom brings about a direct reduction in output in noncoffee tradables, which is reflected in the distance $T_0 T_1$ in Figure 4. The spending effect also leads to an indirect reduction in output of the same sector, given by the distance $T_1 T_2$.

With regard to the wage rate, the resource movement effect leads to a fall in the output of nontraded goods, which is associated with an increase in the wage rate for nontraded goods. Since, for tradables, the wage rate must rise as a result of the resource movement effect, the real wage rate must also rise because of it. On the other hand, the spending effect leads to a rise in both the output and price of nontraded goods and to a fall in the wage rate for nontraded goods. Since the wage rate for traded goods rises because of the spending effect, through the mechanism of real appreciation, the real wage may rise or fall.

Changes in returns to specific factors of production in the three sectors can be measured as the effect of the boom on profitability. It is clear that profitability in noncoffee tradables must fall. Profitability in the nontraded sector would rise if only the spending effect were considered, but the resource movement could cause it to fall. If the output of nontraded goods rises, profitability in this sector must rise for all goods. Finally, profitability in the coffee sector would rise because of the resource movement effect, but it would fall because of the spending effect. A factor specific to the coffee sector does not benefit from the spending effect because the world price of coffee is fixed, and the benefits of the boom could spread to other factors to such an extent that a specific factor could actually lose.

Although it is clear that the returns to a specific factor in noncoffee tradables fall in absolute terms, it is not necessarily so when profitability is measured in relative terms. In fact, if the share of capital in value added in the noncoffee tradables sector is smaller than in other sectors, then a rise in the wage rate reduces its profitability less than the reduction in other sectors. Therefore, a decline in relative profitability

of noncoffee tradables is less likely to occur if this sector is capital-intensive, so that it is less vulnerable than other sectors to the squeeze on profits induced by the increase in wages. Because relative profitability is the force driving resource allocation in the medium run, the boom might in this case increase the output of noncoffee tradables if capital is mobile between sectors.

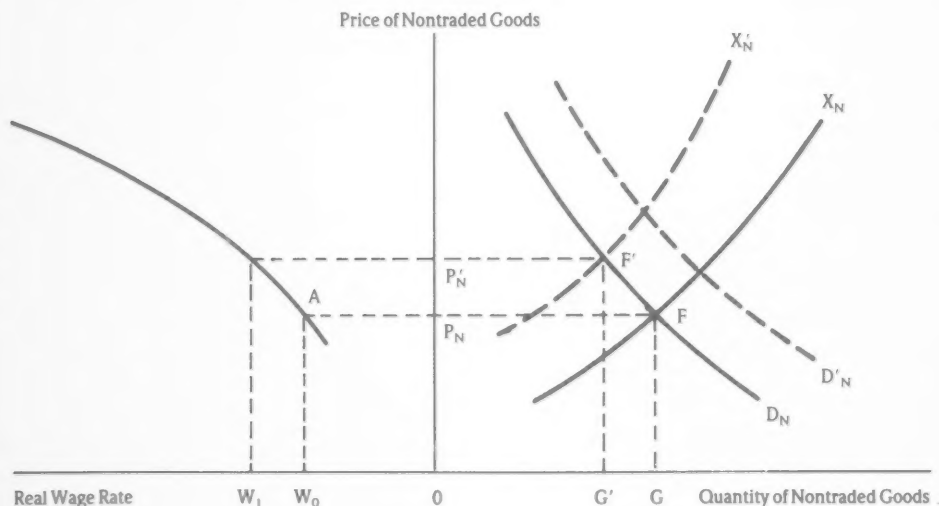
Effects of a Coffee Boom When Capital Is Mobile Between Two Sectors

In the previous case it was assumed that only labor was allowed to move between sectors. In this case capital can be transferred between the noncoffee tradables and the nontraded sectors, but it is sector-specific in the case of coffee. It is helpful for this analysis to view the noncoffee tradable and nontraded sectors as a *rieckscher-Ohlin* model, where a variable supply of labor is equal to the total amount of labor in the economy less the amount employed in the coffee sector. Here there is an unusual relationship between the equilibrium wage rate and the price of nontraded goods, both measured in terms of tradable goods. This relationship is shown in the left-hand side of Figure 6, with an upward-sloping curve reflecting the capital intensity of noncoffee tradables relative to nontraded goods.

Supply and demand curves for nontraded goods are drawn in the right-hand side of Figure 6. The supply curve X_N is upward-sloping, reflecting the normal supply response of the economy. The demand curve D_N is drawn on the assumption that expenditure is equal to income. Equilibrium before the boom is represented by points A and F.

As before, the resource movement effect of the boom is considered separately by assuming zero income elasticity of demand for nontraded goods, so that the demand curve D_N in Figure 6 does not shift. At the initial wage rate, the boom raises the demand for labor of the coffee sector and reduces the amount used in the two sectors

Figure 6—Effects of a coffee boom when capital moves between noncoffee tradable and nontraded sectors



with mobile capital. Following Rybczynsky's theorem, at constant prices the output of the labor-intensive good falls, as reflected in the shift of the supply curve for nontraded goods in Figure 6 from X_N to X'_N , and the displacement of the equilibrium point from F to F'. Output falls from OG to OG', wages rise from W_0 to W_1 , and prices of nontraded goods increase from P_N to P'_N . Thus, in this model a fall in output of nontraded goods must be associated with an increase in output of noncoffee tradables.⁵⁹

The spending effect of the boom induces an outward shift of the demand curve D_N to D'_N , raising output and the price of nontradables while reducing the output of noncoffee tradables. However, the higher price of nontraded goods is only associated with a higher wage rate if the nontradables are relatively labor-intensive as in Figure 6.

In short, if the noncoffee tradables are capital-intensive in relation to nontraded goods, the relative price of nontraded goods will increase, the real wage rate will go up, and the absolute profitability in the two sectors will go down as a result of the coffee boom. The effects of an increase in public expenditure can also be analyzed in this context and will have the same consequences as the spending effect described before.

Empirical Results

The main purpose of this section is to determine empirically the effects of changes in the price of coffee on the income from capital. In this context, capital income should be interpreted as the income from capital and other nonlabor factors of production. Thus, capital income should be understood more broadly as nonlabor income. Similarly, capital intensity should be understood as intensity in nonlabor factors of production. For the rest of this chapter, unless otherwise specified, the terms income from capital and nonlabor income will be used interchangeably.

According to the results presented in the previous section, when the noncoffee tradable sector is more capital-intensive than the nontraded sector, an increase in the price of coffee will increase the relative price of nontraded goods and real wages and decrease the *absolute values* of the capital returns in the nontraded and noncoffee tradable sectors. The information presented in Table 23, processed from national accounts data, shows the share of labor in value added in each of the three categories of coffee, nontradables, and noncoffee tradables. This information tends to support the idea that noncoffee tradables are more capital intensive than nontradables. From the analysis of the previous section and the degree of factor intensity shown in Table 23, it would appear, then, that an increase in the price of coffee would increase the price of nontraded goods and reduce the absolute value of the return to nonlabor income in the nontraded and noncoffee tradable sectors. In other words, the effects of an increase in coffee prices on nonlabor income will be negative in both sectors. The regression models used to estimate the impact of changes in relative prices on absolute real nonlabor income try to do this by relating nonlabor income in each sector to the price of coffee and the real value added of the sector. The estimating equations are as follows:

$$NLY_N = \alpha_0 + \alpha_1 LP_C + \alpha_2 LP_N + \alpha_3 LKVA_N, \quad (39)$$

⁵⁹ If the noncoffee tradables sector is labor-intensive relative to nontradables, the wage rate rises, output of nontraded goods rises, the price of nontraded goods falls, and output of noncoffee tradables also falls.

Table 23—Share of labor income in value added

Year	Importables	Exportables			Noncoffee Tradables	Nontradables	Total
		Coffee	Noncoffee	Total			
				(percent)			
1970	38.8	19.4	35.4	32.4	36.5	42.3	38.7
1971	39.5	18.8	35.6	33.0	36.9	42.6	39.2
1972	38.0	18.4	34.9	32.2	35.9	43.0	38.8
1973	36.3	15.9	33.6	30.4	34.4	42.3	37.5
1974	32.3	18.0	32.9	30.7	32.7	42.2	37.1
1975	35.5	15.4	34.6	31.2	34.9	42.3	37.8
1976	35.5	14.4	35.7	30.9	35.6	41.9	37.3
1977	35.5	17.4	36.9	31.4	36.4	41.7	37.4
1978	38.0	22.9	40.9	36.4	39.8	42.7	40.1
1979	39.4	27.4	41.6	38.5	40.8	43.4	41.4
1980	42.9	25.5	40.1	37.2	41.0	45.4	42.5
1981	43.7	37.3	41.0	40.4	41.8	45.3	43.7
1982	44.6	32.8	40.7	39.6	42.1	45.8	43.9

Source: Derived from Colombia, Departamento Administrativo Nacional de Estadística (DANE), *Cuentas Nacionales de Colombia, 1970-1983* (Bogotá: DANE, 1984); and working sheets for 1970-83 provided by DANE, División de Cuentas Nacionales.

Note: Appendix 1 explains the derivation of these data.

$$\text{and} \quad \text{NLY}_C = \beta_0 + \beta_1 \text{LP}_C + \beta_2 \text{LP}_N + \beta_3 \text{LKVA}_C, \quad (40)$$

$$\text{where} \quad \text{NLY}_T = \gamma_0 + \gamma_1 \text{LP}_C + \gamma_2 \text{LP}_N + \gamma_3 \text{LKVA}_T, \quad (41)$$

NLY_N = logarithm of real nonlabor income in the nontraded sector,

NLY_C = logarithm of real nonlabor income in the coffee sector,

NLY_T = logarithm of real nonlabor income in the noncoffee tradables sector,

LP_C = logarithm of the price of coffee relative to the price of noncoffee tradables,

LP_N = logarithm of the price of nontradables over noncoffee tradables, and

LKVA_j = log of real value added in sector j ($j = C, T, \text{ and } N$).

The results of estimation are presented in Table 24. Equations 1 and 2 in the table measure the effects of changes in the relative price of coffee and nontraded goods on nonlabor income in the nontraded sector. Equations 3 and 4 measure the effects of the same relative price changes on nonlabor income in the coffee sector. Finally, equations 5 and 6 measure the effects of relative price changes on nonlabor income in the noncoffee traded sector.

The results of the regressions in Table 24 support the hypothesis that absolute returns to capital in the nontraded sector decrease with increases in the price of coffee,

Table 24—Estimated effects of relative price changes on nonlabor income in the coffee, noncoffee tradable, and nontradable sectors, 1970-82

Nonlabor Income in Sector/Period	Constant	LP _C		LP _N		Real Value Added					Adjusted R ²	Autocor- relation	Durbin- Watson Statistic
		t	t-1	t-2	t	t-1	Non- traded	Coffee t-1	Noncoffee Traded				
1. Nontraded 1970-82	-0.1583 (-1.0091)	-0.0758 (-3.961)	...	...	...	...	1.1155 (43.6406)	...	...	0.994	...	1.359	
2. Nontraded 1971-82	-2.076 (-3.589)	-0.0653 (-4.758)	...	...	...	...	1.1355 (67.009)	...	...	0.997	-0.377 (-1.13)	2.380	
3. Coffee 1972-82	-7.138 (-3.912)	...	...	0.638 (2.062)	...	...	...	1.905 (5.743)	...	0.828	...	1.840	
4. Coffee 1972-82	-8.0541 (-0.7823)	...	...	0.6829 (1.9292)	...	0.1958 (0.0905)	...	1.9076 (5.369)	...	0.804	...	1.886	
5. Noncoffee traded 1972-82	-10.011 (-10.988)	...	...	...	1.4859 (7.8936)	...	...	...	1.686 (38.347)	0.993	...	2.338	
6. Noncoffee traded 1971-82	-11.1042 (-7.524)	...	-0.0105 (-0.2846)	...	1.8201 (6.3486)	...	...	...	1.6013 (24.4398)	0.982	...	1.760	

Notes: The numbers in parentheses are t-statistics. LP_C is the log of the price of coffee relative to the price of noncoffee tradables, and LP_N is the log of the price of nontradables relative to noncoffee tradables.

whereas returns to capital in the coffee sector increase when the price of coffee goes up. According to the results in Table 24, nonlabor income in the nontraded sector of the economy (equations 1 and 2) declines when there is an improvement in the country's terms of trade. These results indicate that there is probably a significant impact on nonlabor income via the spending effect, which is transmitted relatively quickly to that sector (with a one-year lag). Although significant, this effect is not very strong since a 10 percent increase in the relative price of coffee leads to a decrease of 0.7-0.8 percent in nonlabor income in the nontraded sector. For the coffee sector (equations 3 and 4), however, an increase in terms of trade has a strong effect on nonlabor income. Thus, for every 10 percent increase in the price of coffee, nonlabor income in the coffee sector increases almost 7 percent.

The effect of terms-of-trade changes on the noncoffee tradable sector is presented in equation 6 of Table 24. According to this equation, changes in the terms of trade have a negligible effect on nonlabor income in this sector. Changes in the relative price of nontraded goods and services, on the other hand, have a strong and positive effect on nonlabor income, with an elasticity higher than one. Thus, a 10 percent increase in prices of nontraded goods increases nonlabor income by about 15 percent. This indicates that the effect on labor income of an increase in the price of nontraded goods is negative in the noncoffee tradable sector. This is not, however, the case for labor income in the coffee and nontraded sectors. For the coffee sector, the estimated value of the terms of trade coefficient for nonlabor income is less than one, which indicates that labor income increases when terms of trade improve. For the nontraded sectors, the absolute income of capital falls, which means that total labor income in that sector has to rise.

One interesting point to note about the results of Table 24 is the difference in the lagged effect of changes in coffee prices on nonlabor income in the various sectors, which may be a clue to whether the variations in the price of coffee are more closely related to spending or to resource movement effects. For the nontraded sector (equations 1 and 2), the effect of an increase in the price of coffee on nonlabor income is felt in the current period, which points toward the possibility of an important expenditure effect. However, the impact of terms-of-trade changes are only felt after two years for coffee (equations 3 and 4), and after one year for noncoffee tradables (equations 5 and 6), which may point to the existence of an important resource movement effect.

One final point that should be noted in this context has to do with the issue of factor mobility. As mentioned in the analytical framework of the previous section, the effects of changes in terms of trade on income distribution depend on factor intensity and factor mobility. Some capital mobility between the nontraded and noncoffee tradable sectors, it was found, would permit terms-of-trade improvements to redistribute income toward labor in those sectors. The empirical results presented in Table 24 indicate that indeed an improvement in terms of trade tends to redistribute income toward labor in the nontraded and noncoffee tradable sectors. Therefore, it seems likely that in the short- and medium-terms, some degree of capital mobility between the nontraded and noncoffee tradable sectors of the Colombian economy exists.

Before leaving this subject, it should be stressed that the results presented above are only a first attempt at tackling the problem of measuring the effects of changes in coffee prices on the distribution of income among factors of production. Although the formal model presented here is a complete and fully specified model, it leaves growth aside. Empirical estimation solves this problem, albeit in an inadequate fashion, by incorporating value added as an explanatory variable. However, the growth of value added over time also needs an economic explanation. Thus, a more complete specifica-

tion of the model, which would take into account, among other things, the interaction of factor accumulation, factor prices, and product prices is still required. But data limitations preclude this type of analysis at this stage.

Real Wages in the Agricultural Sector

Labor earnings in agriculture continue to be the lowest in the country. Because a large though declining proportion of the population still lives in rural areas, it is important to gain understanding of the factors contributing to poverty in agriculture. Therefore, since low real wages can be associated with poverty, an analysis of the factors that determine the real wage in agriculture is relevant. To the authors' knowledge no study dealing with the problem of agricultural poverty or income distribution in rural Colombia has approached this problem in the way it is analyzed in this report.

In Colombia, as in many developing countries, urban unemployment coexists with a relatively high real wage in manufacturing, as well as with a more competitive and informal urban labor market. Despite relatively high and rising rates of urban unemployment, there has been a continuous flow of labor from agriculture to the urban sector. Given that these conditions have persisted since World War II, elements of the Todaro model are incorporated in the analysis of real wage determination in agriculture.⁶⁰

People migrate to the city with the expectation of getting a higher-paying urban job. To some extent, the probability of succeeding will depend on the extent of urban unemployment. Thus, one can postulate that the higher the rate of urban unemployment the lower the probability of finding a well-paid job in the urban sector. The lower the probability of getting an urban job, the lower the expected urban wage and the expected gains from migration, and the higher the supply of labor in the rural sector, relative to what it would be otherwise. The Todaro model assumes that the expected urban wage is equal to the average wage of the urban employed and unemployed combined; the weights are the proportions of employed and unemployed in the urban labor force. Equilibrium in the model is attained when the agricultural wage is equal to the expected urban wage. Thus, two elements that will affect the level of real wages in agriculture are the rate of urban unemployment and the real urban wage. Another element that will affect rural real wages is the size of the rural population. The real wage rate in agriculture, the size of the rural population, the rate of urban unemployment, and real urban wages are the factors that affect the supply side of the agricultural labor market.

⁶⁰ The issue of migration and its determinants in Colombia has been the subject of considerable attention. See, among others, William McGreevy, "Causas de la Migración Interna en Colombia," in *Empleo y Desempleo en Colombia* (Bogotá: CEDE, 1968); T. Paul Schultz, *Population Growth and Internal Migration in Colombia* (Santa Monica, Cal.: Rand Corporation, 1969); T. Paul Schultz, *Internal Migration in Colombia: A Quantitative Analysis* (Santa Monica, Cal.: Rand Corporation, n.d.); T. Paul Schultz, "La Modernización del Sector Agropecuario y la Migración Rural Urbana en Colombia," *Revista de Planeación y Desarrollo* (October 1971); Colombia, Ministerio del Trabajo, Servicio Nacional de Empleo, *La Dinámica Interna de los Movimientos Migratorios en Colombia* (Bogotá: Ministerio del Trabajo, 1979); Colombia, Departamento Administrativo Nacional de Estadística, "La Migración Interna y el Proceso de Concentración de la Población en los Departamentos," *Boletín Mensual de Estadística* (No. 314, 1977); Myriam Ordoñez, "Migración y Desempleo en las Ciudades Colombianas," in *Empleo y Desempleo* (Bogotá: Asociación Nacional de Instituciones Financieras, 1977); A. Reyes, *Efectos de la Migración Rural Urbana sobre el Desarrollo Económico y Demográfico* (Bogotá: Corporación Centro Regional de Población, 1975); Gary S. Fields, "Lifetime Migration in Colombia: Tests of the Expected Income Hypothesis," *Population and Development Review* 5 (June 1979): 247-266; and Helena Ribe, "La Posición Económica de los Migrantes y no Migrantes en Colombia," *Desarrollo y Sociedad* 5 (January 1981).

On the demand side, the real wage that agricultural producers are willing to pay will depend on the price of their output and on the productivity of labor. Thus, for a given productivity, the higher the relative price of agricultural products, the more workers agricultural producers are willing to hire. On the other hand, for a given relative price of agricultural output, the higher the productivity of labor in agriculture, the more labor services producers are willing to purchase and the higher the price they are willing to pay for them. It is well established that increases in labor productivity in agriculture have been accompanied by increases in capital in the agricultural sector. Finally, for a given relative price of agricultural output and a given productivity of agricultural labor, the lower the real wage paid in agriculture, the more labor agricultural producers are willing to employ.

Symbolically, these arguments can be presented as follows:

L^S	= supply of agricultural labor,
L^D	= demand for agricultural labor,
W_a	= real wage in agriculture,
W_u	= real urban wage (the wage at which migrants are likely to find employment),
U	= urban rate of unemployment,
PA/PNA	= price of agricultural output (PA) relative to the price of output in the nonagricultural sector (PNA),
N_r	= size of the rural population, and
K_a	= capital stock in agriculture.

The capital stock and the state of technology in agriculture determine the marginal physical product of labor in agriculture. As a result of these assumptions, then the supply of labor in agriculture is given by

$$L^S = L^S(W_a, N_r, U, W_u), \quad (42)$$

and the demand for agricultural labor is given by

$$L^D = L^D(W_a, PA/PNA, K_a). \quad (43)$$

From the previous discussion, the relationship between labor supplied and its determinants are

$$\partial L^S / \partial W_a > 0; (\partial L^S / \partial N_r) > 0; \partial L^S / \partial U > 0; \text{ and } \partial L^S / \partial W_u < 0,$$

and the relationship between labor demanded and its determinants are

$$\partial L^D / \partial W_a < 0; \partial L^D / \partial (PA/PNA) > 0; \text{ and } \partial L^D / \partial K_a > 0.$$

In equilibrium,

$$L^S(W_a, N_r, U, W_U) - L^D(W_a, PA/PNA, K_a) = 0. \quad (44)$$

From equation (44) W_a can be derived as a function of U , W_U , PA/PNA , N_r , and K_a to obtain equation (45):

$$W_a = W_a(PN/PNA, N_r, K_a, U, W_U). \quad (45)$$

From the signs of the partial derivatives of the supply and demand functions for labor, it results that

$$\partial W_a / \partial (PA/PNA); \partial W_a / \partial K_a; \partial W_a / \partial W_U > 0,$$

and

$$\partial W_a / \partial N_r \text{ and } \partial W_a / \partial U < 0.$$

Thus, the real wage in agriculture is a positive function of the relative price of agricultural output, of the capital stock in agriculture, and of the urban real wage, whereas it is a negative function of the size of the rural population and of the urban unemployment rate.

A description of the data used for estimating the real wage equation in the agricultural sector is presented in Appendix 1. Two rates of unemployment are used. One measures unemployment for the four major cities of Colombia (Bogotá, Medellín, Cali, and Barranquilla), using data obtained from a National Household Survey carried out by DANE. Because there is no value given for 1973, it is assumed that the value for that year is the same as for 1972. Alternatively, the regressions are run leaving that year out. The other urban unemployment rate is derived from information given by Corporación Centro Regional de Población (CCRP) on agricultural employment, total employment, and the economically active population. In this case, to derive the rate of urban unemployment, it is assumed that the economically active population in agriculture is equal to the number of people employed in agriculture. The urban rate of unemployment is then defined as the ratio of the difference between total employment and agricultural employment to the difference between the economically active population and agricultural employment.

The wage in the construction sector is taken as the real urban wage rate. The average wage of laborers in this category is derived from information on total labor remuneration from national accounts and from a series on employment for construction as supplied by CCRP. Wages for blue-collar workers in manufacturing were also used as a proxy for the opportunity cost of labor for agriculture. This, however, is not a significant variable and, as argued by Harberger, does not seem to be a relevant variable to capture the true opportunity cost of labor in the urban sector.⁶¹

Two sets of figures for the capital stock are used. The first approximates the capital stock using the ratio of real value added in agriculture to total employment in agriculture. This is based on the idea that the higher the capital stock, the higher the productivity of labor. The second is a measure of capital stock taken directly from Elías' study for the International Food Policy Research Institute.⁶²

⁶¹ See A. C. Harberger, "On Measuring the Social Opportunity Cost of Labor," *International Labour Review* 103 (June 1971): 559-579.

⁶² Elías, *Government Expenditures on Agriculture*.

The equation for estimating real agricultural wages is

$$\log W_a = a + \alpha \log(PA/PNA) + \beta \log K_a + \tau \log W_u + \sigma U + \lambda \log N_r + u, \quad (46)$$

where $\log$ stands for the logarithmic value of the variable, and u is a random term.

The signs for the coefficients α , β , and τ are expected to be positive, while those for σ and λ are expected to be negative. The results of estimation, presented in Table 25, support the hypothesis about the determination of real agricultural wages. The coefficients have the expected sign, are statistically significant, and there are no problems of autocorrelation. One important result that needs to be highlighted is the one concerning the role played by relative agricultural prices. It points to a conclusion that macroeconomic policies that tend to depress agricultural prices work against the economic welfare of the rural population by reducing the real wage.

Table 25—Logarithmic regressions for estimating real agricultural wage equations

Coefficient	1968-83				1968-72, 1974-83	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	34.4932 (4.097)	27.8008 (3.0579)	230.6116 (3.0371)	222.5885 (2.4733)	23.8761 (3.0532)	233.0911 (2.5065)
L(PA/PNA) t	0.5395 (16.4295)	0.5356 (13.9481)	0.4767 (5.4808)	0.5242 (4.8126)	0.5213 (14.0870)	0.5219 (4.6879)
L(K)a (T-1)	...	...	2.8655 (3.8823)	2.6247 (3.2511)	...	2.7216 (3.2605)
L(VAWorker) t	1.4600 (13.1061)	1.4056 (11.1166)	...	...	1.3938 (11.4909)	...
L(RWCONS) t-1	0.2686 (6.1600)	0.2395 (5.0309)	0.4468 (2.6956)	0.3521 (2.1910)	0.2336 (4.9689)	0.3588 (2.1816)
L(rural population) t	-4.2474 (-4.3049)	-3.4843 (-3.2581)	...	-26.8236 (-2.5013)	...	-28.0663 (-2.5332)
t-1	...	...	-27.9585 (-3.0689)	...	-3.0412 (-3.2808)	...
Unemployment rate CCRP t	-0.9399 (-2.8116)	...	-2.9106 (-2.4801)	...	...	...
DANE t	...	-0.3843 (1.7801) ^a	...	-1.6548 (-2.2905)	-0.4782 (-2.0218)	-1.9157 (-2.3529)
Adjusted R ²	0.995	0.992	0.958	0.952	0.993	0.053
Durbin-Watson statistic	2.29	2.30	2.04	2.04	2.516	2.23

Notes: The numbers in parentheses are t-statistics. L(PA/PNA) is the log of the price of agriculture relative to nonagriculture. L(K)a is the log of capital stock in agriculture. L(VAWorker) is the log of real value added per worker in the agricultural sector. L(RWCONS) is the log of real wages in the construction sector. CCRP corresponds to the information on unemployment derived from the Corporación Centro Regional de Población. DANE corresponds to the information on unemployment derived from the Departamento Administrativo Nacional de Estadística.

^a Significant at 95 percent.

CONCLUSIONS

This report integrates the analysis of developments in Colombian agriculture between 1967 and 1983 with external developments and domestic macroeconomic policies. The analysis examines how external events and domestic policies affect the real exchange rate and relative prices in agriculture. It also looks at the effects of external terms-of-trade changes on the distribution of income between labor and nonlabor factors of production in traded and nontraded sectors, and on the determinants of real wages in agriculture. In addition, by examining the supply response of rice, cotton, wheat, coffee, livestock, and aggregate agricultural output to price changes, the importance of understanding the factors that affect the relative prices of broad aggregates of products is established. Although the report emphasizes the importance of macroeconomic policies, it should not be thought that microeconomic policies are not important for agriculture. But the success or failure of many microeconomic policies depends on the successful conduct of domestic macroeconomic policies, as well as on the adequate response of government to external shocks.

The report shows that relative prices are closely linked to developments in the international economy and to domestic economic policies. Therefore, the ability of the government to respond to changes in external circumstances or to conduct reasonable economic policies is an important element of agricultural policy broadly understood.

The first thing that comes out of the analysis in Chapter 4 is that an improvement in the terms of trade from an increase in the international price of coffee is not necessarily good for the rest of the traded sectors of the economy if this gain is not adequately offset by other policies that reduce the expenditure effect arising from the gains in terms of trade. Fiscal policy that reduces government expenditures is an obvious choice to avoid a fall in the relative price of traded goods other than coffee resulting from a coffee boom. During the 1975-77 coffee boom, this approach was tried. Central government expenditures were reduced, but not enough to avoid a decline in the relative price of noncoffee tradables. In fact, the results of Chapter 4 indicate that the size of the consolidated public sector is what matters most when looking at the effects of government expenditure on relative prices. But, as the data in Table 7 show, the size of the consolidated public sector remained more or less the same during this period.

Another obvious policy that can help avoid this decline in relative price is to tax the gains in terms of trade and to save the revenue originating in these taxes for future use. However, if the revenue from the taxation of these gains is accompanied by a corresponding increase in government expenditure, the negative impact of this policy on the relative price of noncoffee tradables will be larger than if the gains had been left entirely to coffee producers. This is so because the positive relationship found between size of government and the relative price of nontraded goods tends to support the presumption that the government's propensity to save is lower than the private sector's propensity to save. Taxation of these gains is not necessarily the only way the boom could be handled. In fact, exporters could be allowed or encouraged to leave part or all of their "above normal" revenues outside of the country while the boom lasts and to bring them into the country when the boom ends.

The decision to bring in the money or leave it out, however, would depend on the institutional arrangements in operation. At this moment in Colombia, all foreign ex-

change proceeds from exports have to be sold immediately to the Central Bank at a fixed exchange rate established by the government. Under this system, the initial gains of the boom go to the coffee sector because its revenue increases faster than domestic prices, and the expenditure effect occurs fairly quickly. However, under a fully flexible exchange rate system, the additional dollar revenues arising from the increase in terms of trade would have to be sold at a lower price thus leading exporters to save and retain part of their earnings abroad.

Another conclusion that emerges from the analysis presented in this report is that a tariff applied to coffee exports on the grounds of an optimum tariff argument will have the same effect as a coffee boom induced by exogenous changes in the world supply resulting from shortfalls in production in one of the major producing countries. In other words, if the optimum tariff argument for Colombian coffee is valid, that tariff will have the same effect as a coffee boom, qualitatively speaking, on the relative prices of traded goods. Moreover, as the estimated coefficients in Tables 11 and 12 indicate, the effects of terms-of-trade changes on relative prices of noncoffee traded commodities is stronger on the importable than on the exportable sector of agriculture. In this case, the more or less permanent gains for coffee arising from the imposition of an optimum tariff imply losses for the rest of the traded sector. As the promotion and diversification of exports has been a constantly stated policy goal for the last 20 years, an obvious recommendation arising from this analysis is to spend the revenues from the export tariff on coffee to compensate for or subsidize noncoffee exports by the resulting appreciation of the peso.

Also important is the confirmation of previous findings about the positive response of agricultural output to changes in prices. This point must be stressed, because the dismal performance of agriculture in the second half of the 1970s and early 1980s is attributed by many to the competition of imports. Although it is true that imports increased in the second half of the 1970s at faster rates than observed previously, they did not make large enough inroads to produce such a sharp change in the rate of growth of agricultural production. The findings on the positive response of output to price changes and the decline of relative agricultural prices in the second half of the 1970s and early 1980s largely explain the relative decline of agricultural production and the fall of agricultural exports during that period. As the results on the determination of relative prices in agriculture show, increasing government expenditure in order to reactivate the economy, as is usually argued, is not a solution to the problem of lagging agricultural growth, as such increased expenditure may reduce relative prices for agriculture.

Finally, to reduce domestic interest rates administratively in order to increase expenditure and avoid a recession in agriculture is seldom a successful policy because the interest rate is determined largely by international interest rates, the rate of devaluation, and domestic inflation. Also, administered interest rates cannot be used to change relative prices through their effect on the composition of expenditure between traded and nontraded commodities, as interest rates are mostly determined by forces that are directly out of control of the government.

The analysis of the determination of real agricultural wages shows that three elements that affect wages and that are also influenced by government policy are the terms of trade between agriculture and nonagriculture, the rate of urban unemployment, and the stock of capital in the rural sector. When an import substitution model was adopted that promoted and protected industry at the expense of agriculture, the terms of trade between agriculture and nonagriculture fell, leading to a decline in real wages in agriculture. In addition, the discouragement of capital accumulation acted against higher real wages in agriculture.

These findings have important implications for policymaking, especially when dealing with the problem of the eradication of poverty in rural areas. Several points merit consideration. First, policies that artificially depress agricultural prices tend to reduce real agricultural income and worsen rural poverty. Thus, since Colombian agriculture is mainly an exportable sector, the implementation of import substitution policies to promote industrialization does reduce the price of agricultural commodities relative to prices in the rest of the economy, and this in turn reduces real agricultural wages. The same is true for policies that reduce the price of food or subsidize imports of food products to increase the real income of the urban population. Second, because farmers do respond to prices, the accumulation of capital is discouraged when agricultural prices are artificially lowered, which reduces real wages below the level they would have been otherwise. Third, the establishment of minimum urban wages also may increase poverty in agriculture. This is because minimum wages increase urban unemployment, reduce the expected real income of the migrant, and push the supply of rural labor above what it would be otherwise, thus driving rural wages down.

APPENDIX 1: DATA SOURCES AND METHODS⁶³

Prices of Traded and Nontraded Goods

The objective of constructing a price data base was to generate prices for broad categories of products including exportables and importables (called tradables) and nontraded (home) goods. To obtain relative prices, implicit price deflators for each category were generated. For this, information was needed on constant and current prices. The period covered goes from 1970 to 1983 when the information required is available.

Information for 38 agricultural products and for 70 subgroups of the industrial sector was available. No disaggregation was done for the forestry, fishing, mining, and services sectors due to time constraints. Published data from Departamento Administrativo Nacional de Estadística's (DANE), *Matrices de Insumo Producto* were used. Information at the product or group level was obtained from what are known as equilibrium worksheets in DANE's Division of National Accounts. For some periods, mainly between 1970 and 1975, the aggregation of the individual information does not match the aggregate published information in the input-output matrixes.

The following sections explain how the agricultural and industrial sectors are classified by DANE by products and groups of products, how the individual information was matched with the aggregate published information, and how the missing information was generated. For this exercise the generous collaboration of staff of DANE's Division of National Accounts was invaluable.⁶⁴

Agricultural Sector

DANE defines the agricultural sector as the sum of sectors 01 ("pergamino" coffee), 02 (agriculture), and 03 (livestock, including dairy cattle, poultry, and other species of livestock). Sectors 08 (processed coffee) and 12 (sugar manufacturing) were added to DANE's definition of agriculture to generate what in this report is called broad agriculture (01-03,08,12).

Industrial Sector

DANE defines the industrial sector as the sum of sectors 08 to 25. In this report the industrial sector is defined as the sum of sectors 09-11 and 13-25, since 08 and 12 have been added to the agricultural sector. Due to the diversity of products manufactured in the industrial sector, information is not available by products but only at the subgroup and group levels of products.

No information is provided by DANE on the magnitude of trade in illegal drugs such as cocaine and marijuana, which explains why they are not included in this report.

Modifications to DANE's Unpublished Data

The classification here is the most disaggregated that can be found in national accounts. However, the classification system and the information varies over time as

⁶³ This section is based on Jorge García García's "Metodología Utilizada para Obtener Datos de Cuentas Nacionales para Industria y Agricultura," Bogotá. 1986 (mimeographed).

⁶⁴ The help of Evaristo Arrieta, Jorge Centanaro, and Néstor Carrasco, in particular, is gratefully acknowledged.

one product or group of products becomes more or less important. Moreover, in some cases the amount of disaggregation and the classification for a product or group of products are different depending upon whether the information is given in current or constant prices. For agriculture, it is necessary to aggregate various products to generate a "new" product.

The aggregation of information from DANE's worksheets does not match exactly the published information. For the agricultural sector (01-03), matching problems are more serious because the information is published for the aggregate of sectors 01, 02, and 03. However, unpublished information for each of these sectors is available from DANE. Sector 01 is one product ("pergamino" coffee) and does not present any problems.

For some products in sector 02 (raw tobacco [02.3], cottonseed [02.7.7], and cotton fiber [02.8.1]) and in sector 03 (other animal production [03.4]) there is more than one worksheet, which means that there is more than one value for each indicator of the product. For those products the selected value is, among the various possible values, the one that minimizes the difference between the published value (or the unpublished value from DANE's input-output matrixes) and the value calculated as the aggregation of individual values. Once this first step in the cleaning process is completed, some differences still remain; to eliminate them, the procedure suggested by the DANE staff and described below was followed.

For information at current prices, the principal inconsistencies are found in the 1970-74 years, when DANE's system of national accounts began to be developed. During this period DANE made corrections to the aggregate information, but these corrections were not shifted back to the worksheets of the individual products. Corrections were then made on the products suggested by DANE's staff, but when differences still remained these were allocated proportionally among products or subgroups of products in order to maintain the initial composition within each subgroup or group.

Information at constant prices at the product level is not available in DANE's worksheets for the period 1970-74, but it can be generated from current price data using the following procedure. From the working sheets it is possible to calculate indexes of volume for each variable (output, for example) by dividing its value for year t at prices of year $t - 1$; that is,

$$IVOL_{t,t-1} = Q_t^* P_{t-1} / Q_{t-1}^* P_{t-1}, \quad (47)$$

where $IVOL_{t,t-1}$ is the index of volume between years t and $t - 1$. Defining

$$I_{(t/t-1)} = Q_t^* P_{t-1}, \quad (48)$$

and

$$I_{(t-1/t-1)} = Q_{t-1}^* P_{t-1}, \quad (49)$$

then

$$IVOL_{t,t-1} = I_{(t/t-1)} / I_{(t-1/t-1)}. \quad (50)$$

Thus, the series can be reconstructed backward if the value of the indicator for the base year, 1975, is known. Dividing the nominal value of the indicator for the year t at the price of year $t - 1$ by the volume index for the year $t/t - 1$, the absolute value of the indicator for the year $t - 1$ is generated. For example, if $IVOL_{(75/74)}$ is defined as the volume index between 1975 and 1974 and $I_{(75/75)}$ as the absolute value of the indicator in the base year 1975, then the absolute value of the indicator in 1974 at 1975 prices [$I_{(74/75)}$] is defined as

$$I_{(74/75)} = I_{(75/75)} / IVOL_{(75/74)} \quad (51)$$

This procedure is applied to obtain the value of the indicator for each year prior to 1974. It is valid for those cases in which the value for the base year is positive, but not for those cases where it is zero. To obtain the real value for the latter, the nominal value for any year t is deflated by the price index for that product and year. A summary of the modifications to each product with data problems can be found in Jorge García García's "Metodología Utilizada para Obtener Datos de Cuentas Nacionales para Industria y Agricultura," Bogotá, 1986.

After the value for the indicator of each product is generated, differences between the sum of the values so generated and the published ones are still present. These differences are eliminated by distributing them proportionally within each group, as explained above for the nominal values.

Classification of Exportables, Importables, and Nontraded Goods

Each product or group of products is classified into one of the following categories: import-competing (MC), noncompeting imports (MNC), exportables (X), and nontraded goods (N). To classify each product in one of these categories, a statistic T is computed.⁶⁵ This statistic is defined as

$$T = (\text{Consumption} - \text{Production}) / \text{Consumption}, \quad (52)$$

where

$$\text{Consumption} = \text{Production} + \text{Imports c.i.f.} - \text{Exports f.o.b.} \quad (53)$$

Production is measured at producer prices. Each product is classified according to the following general criteria:

$$T < 0, \text{ exportable (X)} \quad (54)$$

$$T = 0, \text{ nontraded (N)}, \quad (55)$$

$$0 < T \leq 0.4, \text{ import-competing (MC), and} \quad (56)$$

$$0.4 < T \leq 1, \text{ noncompeting imports (MNC)}. \quad (57)$$

In addition to the above criteria, some other considerations are used to classify a commodity in a certain category. For example, in DANE's national accounts classification, coffee is divided into two groups: pergamino or unwashed (group 01) and processed or washed (group 08). The value of T for pergamino coffee is zero because pergamino

⁶⁵ This statistic is used in Anne O. Krueger, ed., *Trade and Employment in Developing Countries: Vol. 1 Individual Studies*, for the National Bureau of Economic Research (Chicago: University of Chicago Press, 1981), p. 17; and Anne O. Krueger, *Trade and Employment in Developing Countries: Vol. 3 Synthesis and Conclusions*, for the National Bureau of Economic Research (Chicago: University of Chicago Press, 1983), p. 89. The first one to use this classification for Colombia was Francisco E. Thoumi, "International Trade Strategies, Employment and Income Distribution in Colombia," in *Trade and Employment in Developing Countries: Vol. 1 Individual Studies*, ed. Anne O. Krueger (Chicago: University of Chicago Press, 1981), pp. 135-179.

coffee is not sold abroad, but it is very high for processed coffee. However, the domestic price of pergamino coffee is influenced by the international price of coffee, and for that reason pergamino coffee is classified as an exportable. In cases where the volume of gross and net trade is small and T is close to zero but without any defined pattern over the period, the products are classified as nontraded. In other cases, where $T = 0$ and imports of commodities are not registered but clear evidence of smuggling is present, the commodities are classified as import-competing or noncompeting imports (for example, television sets, transistor radios, cameras, and similar products fall in this category). Finally, in cases where $T = 0$ but there is clear evidence that industries cannot survive without the imposition of quota restrictions or extremely high tariffs (cars and other transport equipment, for example), the commodities are classified as noncompeting imports.

The above procedure generates categories of exportables, importables, and nontraded goods for the period 1970-83. Using a different method, information on prices for these categories is generated for the period 1967-69. Based on knowledge gained from the exercise for the period 1970-83, most of the industrial sector is identified as importable, most of the agricultural and mining sectors are identified as exportable, and most of the services sector is identified as nontraded. Because the information available from Banco de la República for this period does not lend itself to the above method, the industrial sector is taken as the importable sector, most of agriculture and the whole of mining as the exportable sector, and services as the nontraded sector. The set of relative prices generated for the importable, exportable, and nontraded sectors for the period 1967-69 corresponds to prices of value added, while that generated for the 1970-83 period refers to prices for gross value of output.

To generate prices for 1967-69 for tradable, noncoffee tradable, coffee, and nontraded categories in agriculture, information on output and prices from Banco de la República's national accounts is used, keeping in mind that the constant price series from Banco de la República valued at 1958 prices has to be converted to 1975 prices.

The price of pergamino coffee as supplied by Banco de la República converted to a 1975 base is used, 1970 being the common year to bridge the gap in the series. The coffee price for the series at 1975 prices corresponds to the price of pergamino and processed coffee combined (01 + 08). For noncoffee tradables in agriculture, the value of output corresponds to the difference between the value of output for the main agricultural products plus livestock minus the value for coffee output. The group called "other products" by Banco de la República is classified as nontraded.

Tables 26, 27, and 28 present the classifications adopted for each product, subgroup, or group of products from DANE's national accounts classification for agriculture, industry, and the rest of the sectors of the economy.

Data and Sources for Other Variables

Value Added

Nominal and real value added and nominal labor remuneration for each individual product in agriculture or each subgroup in industry are obtained assuming that the relationship between value added and gross value of output for each individual product is equal to the relation between value added and gross output for the sector producing that product. Total real labor remuneration by sector is found by multiplying the share of labor in nominal value added by real value added in each sector because DANE's national accounts do not provide the information in real terms.

Table 26—Classification of agricultural products by categories: food and nonfood, traded and nontraded, 1970-82

Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
01 Pergamino coffee													
02.1 Cereals													
02.1.1 Wheat	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF	MNCF
02.1.2 Corn	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.1.3 Barley	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.1.4 Rice	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF
02.1.5 Sorghum	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.1.6 Oats	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.2 Sugarcane													
02.2.1 Sugarcane (sugar)	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF
02.2.2 Sugarcane (brown sugar)	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.3 Raw tobacco	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF
02.4 Tubers													
02.4.1 Potatoes	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.4.2 Cassava	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.4.3 Yams	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.4.4 Other tubers	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.5 Vegetables and legumes													
02.5.1 Tomatoes	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.5.2 Other vegetables	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.5.3 Red beans	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.5.4 Beans	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.5.5 Other	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.6 Fruit													
02.6.1 Bananas													
02.6.1.1 Bananas for export	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF
02.6.1.2 Bananas for internal consumption	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.6.2 Other fruit	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.7 Oil products													
02.7.1 Soybeans	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.7.2 Peanuts, coconuts, copra	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.7.5 Sesame	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF	XF
02.7.6 African palm	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
02.7.7 Cottonseed	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
02.8 Fiber													
02.8.1 Cotton	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF	XNF
02.8.2 Jute	NNF	NNF	NNF	NNF	NNF	NNF	NNF	NNF	NNF	NNF	NNF	NNF	NNF
02.9 Other agricultural products													
02.9.1 Plantains	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF

(continued)

Table 26—Continued

[illegible]

Sources: National accounts classification from Colombia, Departamento Administrativo Nacional de Estadística, Division de Cuentas Nacionales, "Metodología de las Cuentas Nacionales de Colombia—Según el Nuevo SCN (Version Preliminar)," Bogotá, January 1979 (mimeographed); the classification by traded and nontraded goods is from Jorge García García, "Metodología Utilizada para Obtener Datos de Cuentas Nacionales no Insumidos," Bogotá, 1980 (mimeographed).

Notes: XNF is exportable nonfood. MNCF is noncompeting food imports. XF is nonfood.

Notes:

nonfood. MF is importable food. XF is exportable food. MNF is nontraded food. NF is nontraded food. MNF is importable nonfood. MF is importable food. XF is exportable food. MNF is nontraded food. NF is nontraded food. MNF is importable nonfood.

Table 27—Classification of processed and industrial products by categories: traded and nontraded, 1970-82

Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
9 Meat													
1 Meat	X	X	X	X	X	X	X	X	X	X	X	X	X
2 Processed meat	M	M	M	M	M	M	M	M	M	M	M	M	M
3 Fish products	X	X	X	X	X	X	X	X	X	X	M	M	M
10 Cereal products													
1 Flour	M	M	M	M	M	M	M	M	M	M	M	M	M
2 Other milling products	X	X	X	X	X	X	X	X	X	X	X	X	N
3 Bread	N	N	N	N	N	N	N	N	N	N	N	N	N
4 Other cereals	X	X	X	X	X	X	X	X	X	X	X	X	X
5 Animal feeds	M	M	M	M	M	M	M	M	M	M	M	M	M
11 Milk products													
1 Liquid milk	M	M	M	M	M	M	M	M	M	M	M	M	M
2 Cream	X	X	X	X	X	X	X	X	X	X	X	X	X
3 Concentrated milk	M	M	M	M	M	M	M	M	M	M	M	M	M
4 Ice cream and related products	N	N	N	N	N	N	N	N	N	N	N	N	N
5 Other milk products	N	N	N	N	N	N	N	N	N	N	N	N	N
13 Beverages													
1 Nonalcoholic beverages	N	N	N	N	N	N	N	N	N	N	N	N	N
Beer	N	N	N	N	N	N	N	N	N	N	N	N	N
3 Wine	M	M	M	M	M	M	M	M	M	M	M	M	M
4 Other alcoholic beverages	M	M	M	M	M	M	M	M	M	M	M	M	M
5 Malt and cereal germs	M	M	M	M	M	M	M	M	M	M	M	M	M
14 Tobacco products	M	M	M	M	M	M	M	M	M	M	M	M	M
15 Other processed agricultural products													
1 Oils and margarine	M	M	M	M	M	M	M	M	M	M	M	M	M
2 Fruit and legume products	M	M	M	M	M	M	M	M	M	M	M	M	M
3 Chocolates and candies	M	M	M	M	M	M	M	M	M	M	X	X	X
4 Other foodstuffs	N	N	N	N	N	N	N	M	X	X	M	M	M
5 Dietetic products	N	M	M	M	X	X	X	X	X	X	X	X	X
16 Textiles, apparel, and leather													
1 Textiles	X	X	X	X	X	X	X	X	X	X	X	X	M
2 Handworks of textile materials	M	M	M	X	X	X	X	X	X	X	X	X	X
3 Apparel	X	X	X	X	X	X	X	X	X	X	X	X	X
4 Tanned leathers	X	X	X	X	X	X	X	X	X	X	X	X	X
5 Shoes and leather products	X	X	X	X	X	X	X	X	X	X	X	X	X
17 Wood and wood products													
1 Processed wood	X	X	X	X	X	X	X	X	X	X	X	X	X
2 Cork and wood products	M	M	X	X	X	X	X	X	X	X	X	X	X
3 Wood furniture	X	X	X	X	X	X	X	X	X	X	X	X	X
18 Paper and printing													
1 Pulp	M	M	M	M	M	M	M	M	M	M	M	M	M
2 Paper and cardboard	M	M	M	M	M	M	M	M	M	M	M	M	M
3 Paper and cardboard products	M	M	M	M	M	M	X	X	M	X	M	M	M
4 Printing and similar materials	M	M	M	M	M	M	M	X	X	M	X	X	X
19 Chemicals and rubber													
1 Base products	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
2 Fertilizers and insecticides	M	M	M	M	M	M	M	M	M	M	M	M	M

(continued)

Table 27—Continued

Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
3 Synthetic resins and artificial fibers	M	M	M	M	M	M	M	M	M	M	M	M	M
4 Plastic products	M	M	M	M	M	M	M	M	M	M	M	M	M
5 Rubber and rubber products	M	M	M	M	M	M	M	M	M	M	M	M	M
6 Color, varnish, and lacquer	M	M	M	M	M	M	M	M	M	M	M	M	M
7 Pharmaceutical products	M	M	M	M	M	M	M	M	M	M	M	M	M
8 Toilet products	M	M	M	M	M	M	M	M	M	M	M	M	M
9 Other products	M	M	M	M	M	M	M	M	M	M	M	M	M
20 Petroleum refining	X	X	X	X	X	X	X	M	M	M	M	M	M
1 Refined petroleum	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2 Other petroleum products	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
21 Nonmetal products													
1 Clay and porcelain objects	X	X	X	X	X	X	X	X	X	X	X	X	X
2 Glass and glass products	M	M	X	X	X	X	X	X	X	X	X	M	M
3 Other mineral non-metallic products	X	X	X	X	X	X	X	X	X	X	X	X	X
22 Base metal products													
1 Basic iron and steel products	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
2 Basic nonferrous products	M	M	M	M	M	M	M	M	M	M	M	M	M
3 Other processed products	M	M	M	M	M	M	M	M	M	M	M	M	M
23 Machinery and equipment													
1 Agricultural machinery and equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
2 Machinery for metal and wood	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
3 Industrial machinery and equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
4 Office equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
5 Radio, TV, communications equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
6 Household appliances	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
7 Electric equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
8 Other equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
24 Transport materials													
1 Ships and repairs	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
2 Railway equipment and repairs	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
3 Automotive vehicles	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
4 Airplanes and repairs	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
5 Other transport materials	M	M	M	M	M	M	M	M	M	M	M	M	M
25 Other manufactured													
1 Professional and scientific equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
2 Optic and photographic equipment	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
3 Clocks and jewelry	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC
4 Musical instruments and others	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC	MNC

Sources: National accounts classification from Colombia, Departamento Administrativo Nacional de Estadística, División de Cuentas Nacionales, "Metodología de las Cuentas Nacionales de Colombia—Según el Nuevo SCN (Version Preliminar)," Bogotá, January 1979 (mimeographed); the classification by traded and nontraded goods is from Jorge García García, "Metodología Utilizada para Obtener Datos de Cuentas Nacionales para Industria y Agricultura," Bogotá, 1986 (mimeographed).

Notes: MNC is noncompeting importable goods. M is importable. X is exportable. N is nontraded.

Table 28—Classification of forestry, fishing, mining, and services by categories: traded and nontraded, 1970-82

Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
04. Forestry	X	X	X	X	X	N	N	N	N	N	N	N	N
05. Fishing and hunting	X	X	X	X	X	X	X	X	X	X	X	X	X
06. + 07. Mining	X	X	X	X	X	X	X	M	M	M	X	X	X
26. Electricity, gas, water	N	N	N	N	N	N	N	N	N	N	N	N	N
27. Construction, public works	N	N	N	N	N	N	N	N	N	N	N	N	N
28. Commerce	N	N	N	N	N	N	N	N	N	N	N	N	N
29. Transport	X	X	X	X	X	X	X	X	X	X	X	X	X
30. Communications	N	N	N	N	N	N	N	N	N	N	N	N	N
31. Banking, insurance, and other services	N	N	N	N	N	N	N	N	N	N	N	N	N
32. Housing rental	N	N	N	N	N	N	N	N	N	N	N	N	N
33. Personal services	N	N	N	N	N	N	N	N	N	N	N	N	N
34. Government services	N	N	N	N	N	N	N	N	N	N	N	N	N
35. Domestic services	N	N	N	N	N	N	N	N	N	N	N	N	N

Sources: National accounts classification from Colombia, Departamento Administrativo Nacional de Estadística, Division de Cuentas Nacionales, "Metodología de las Cuentas Nacionales de Colombia—Según el Nuevo SCN (Version Preliminar)," Bogotá, January 1979 (mimeographed); the classification by traded and nontraded goods is from Jorge García García, "Metodología Utilizada para Obtener Datos de Cuentas Nacionales para Industria y Agricultura," Bogotá, 1986 (mimeographed).

Notes: M is importable. X is exportable. N is nontraded.

Real Wages and Employment

The information on real wages and employment is derived from the following sources:

From 1967 until 1982 the nominal wage for the manufacturing sector is derived from DANE, *Encuesta Anual Manufacturera* (various years), and corresponds to the blue-collar wage. To obtain real wages, three deflators are used: the implicit price of manufacturing output, the GDP deflator, and the price of noncoffee tradables. For 1983, it is assumed that the nominal wage increased by 23 percent, the rate of increase in the legal minimum wage. The information for real unit cost of labor and the index of nominal manufacturing wages are taken from Jorge García García, "The Timing and Sequencing of Trade Liberalization: The Case of Colombia Part II, The Analysis of Liberalization Episodes," a paper prepared for World Bank Research Project RPO 673-31, Bogotá, February 1986 (mimeographed) Table D.1.c.3.

The index of real agricultural wages is derived from real wages taken directly from Sociedad de Agricultores de Colombia (SAC), *Revista Nacional de Agricultura Separata*, No. 867 (June 1984), for the period 1967-82. For this set, the value for 1983 is obtained by applying the rate of growth of real agricultural wages derived from national accounts.

To obtain real wages in construction, the wage bill for the construction sector is divided by the number of people employed in the sector. The nominal wage bill is taken from Banco de la República's *Cuentas Nacionales* until 1980, and it is extended to 1981, 1982, and 1983 by applying the corresponding annual rate of growth of the wage bill for the construction and public works sector from DANE's *Cuentas Nacionales* (Sector 27). Direct information on employment in the construction sector from CCRP's Area Socioeconómica, *Modelo de Corto Plazo* is used.

The sources for DANE's urban unemployment rate are household surveys including DANE, *Encuesta de Hogares, EH-19 to EH-28*; DANE, *Colombia Estadística: 1985*

(Bogotá: DANE, 1985), Table 5.1, for 1969-83; and Centro de Estudios sobre Desarrollo Económico, *Empleo y Desempleo en Colombia* (Bogotá: CEDE, 1968) for 1967-68. The rate of urban unemployment derived from CCRP data is obtained as the ratio of the difference between total and agricultural employment to the difference between the total economically active population and agricultural employment.

Consolidated Government Expenditure and Deficit

No single source covers the period 1967-83. The sources of this information are Departamento Nacional de Planeación, Misión Bird-Wiesner, *Finanzas Intergubernamentales en Colombia* (Bogotá: Printer Colombiana, 1981), p. 26, Table II-1 for the period 1967-72; and Colombia, Departamento Nacional de Planeación, "Consolidación Financiera del Sector Público Colombiano: 1973-1982," Bogotá, September 1984 (mimeographed). For 1983 the information on consolidated government expenditure is estimated assuming that total expenditure increased 30 percent.

Interest Rates

The domestic interest rate is obtained from Gabriel Montes and Ricardo Candelo, "El Enfoque Monetario de la Balanza de Pagos: El Caso de Colombia 1968-1980," *Revista de Planeación y Desarrollo* (May-August 1982), Annex Table 1 for 1968-73; and from Patricia Correa, "Determinantes de la Cuenta de Servicios de la Balanza Cambiaria," *Ensayos sobre Política Económica* (December 1984), Annex Table 3 for 1974-83. The annual rate is obtained as an arithmetic average of the quarterly rates from these sources. The interest rate for 1967 is assumed to be equal to that of 1968.

The external rate of interest is given by the Eurodollar rate in London, which is taken from International Monetary Fund (IMF), *International Financial Statistics Yearbook 1984* (Washington, D.C.: IMF, 1984), United Kingdom page, line 60d.

The domestic real interest rate is defined as

$$r = (1 + i) / [1 + (dP/dT)(1/P)] - 1, \quad (58)$$

where

r = real interest rate,
 i = nominal interest rate,
 P = implicit GDP deflator, and
 $(dP/dT)(1/P)$ = percentage change in prices.

The parity interest rate is defined as

$$pr = (1 + r^*) / [1 + (dE/dT)(1/E)] - 1, \quad (59)$$

where

pr = parity interest rate,
 r^* = external interest rate,
 E = nominal exchange rate, and
 $(dE/dT)(1/E)$ = percentage change in the nominal exchange rate.

Money, the Monetary Base, and International Reserves

Money is defined as currency plus demand deposits, and the yearly figure is a 12-month average for each year. The monetary base is defined as currency plus reserves

of the commercial banks in Banco de la República. The source of this information is Banco de la República, *Revista del Banco de la República* (various issues). The change in international reserves is derived from IMF, *International Financial Statistics: Supplement on Balance of Payments No. 7* (Washington, D.C.: IMF, 1984), p. 40. The peso value of the change in international reserves is calculated by multiplying its special drawing rights (SDR) value by the average peso exchange rate for the SDR in each year.

Physical Capital, Employment, and Land

Physical capital is taken directly from Víctor J. Elías, *Government Expenditure on Agriculture and Agricultural Growth in Latin America*, Research Report 50 (Washington, D.C.: IFPRI, 1985), Table 31. The information from Elías covers the 1967-80 period. For 1981-83 it is assumed that the rate of growth of the capital stock in agriculture is equal to the rate of growth of the capital stock for the whole economy, and the latter is taken from Jorge García García, "The Timing and Sequencing of Trade Liberalization, The Case of Colombia," Statistical Appendix to Part I (magnetic files).

Direct information on agricultural employment from CCRP's "Modelo de Corto Plazo" is used. Land used in agriculture is also taken from Elías, *Government Expenditure on Agriculture*, Table 31, for the period 1967-80. For 1981 to 1983 it comes from SAC, "Perspectivas Económicas Generales," *Revista Nacional de Agricultura* 870 (March 1985), Table 3.

Terms of Trade

The external and internal terms of trade were obtained as

- TTBS = implicit price of exports of goods and services/implicit price of imports of goods and services, derived from Banco de la República, *Cuentas Nacionales* for 1967-69, and from DANE's *Cuentas Nacionales* for 1970-83.
- PAPNA = implicit price of agricultural output/implicit price of output in the nonagricultural sector. This was derived from Banco de la República's *Cuentas Nacionales*, 1967-1971 for the 1967-69 period, and from DANE's *Cuentas Nacionales* for broad agriculture (01-03, 08, 12) for the 1970-83 period.

Areas, Output, and Prices

Cotton data for 1960-66 are from Jorge García García, "The Economics of Cotton Growing in Colombia," IFPRI, Washington, D.C., 1979. Those for 1967-83 are from Federación Nacional de Algodoneros, *Informe del Gerente al Congreso Nacional de Algodoneros* (Bogotá: FNA, various years).

Rice data are from Federación Nacional de Arroceros, *Un Gremio al Servicio de Colombia* (Bogotá: OP Grafica, 1985) for area, 1960-83, and for price, 1981-83. Rice prices for 1960-80 are supplied directly by Banco de la República, División de Cuentas Nacionales, Departamento de Investigaciones Económicas.

Area of wheat data for 1953-83 come from Oficina de Planeación del Sector Agropecuario, Ministerio de Agricultura, *Estadísticas del Sector Agropecuario*, various years. Output from 1950-81 came from Banco de la República, Departamento de Investigaciones Económicas, and direct information from SAC, for 1982 and 1983. Coffee data are

from Bateman, *Supply Response in the Colombia Coffee Sector*, Table 2, and livestock data are from Rivas and Valdés, "Evolución del Inventario Vacuno de Colombia," Tables A1-A5 and Appendix B.

Prices of Milk and Soybean

Milk and soybean prices for 1950-81 were supplied by Banco de la República, División de Cuentas Nacionales, Departamento de Investigaciones Económicas, for 1950-1981, and those for 1982 and 1983 came from SAC.

Finally, the additional basic Colombian data necessary for the evaluations presented in the report are given in Appendix 3, Tables 29 to 32.

APPENDIX 2: A DEMOGRAPHIC MODEL FOR THE COLOMBIAN LIVESTOCK SECTOR: 1940-75

The demographic model used in this report to generate stocks of animals of different ages has already been applied to Colombia by Rivas and Valdés.⁶⁶

The basis of this model is the estimation of male births of beef cattle in period t (MB_t) based on information on male slaughter in period $t + \lambda$ ($MS_{t+\lambda}$), death rates for animals younger and older than one year in period t (m_t^* and m_t , respectively), and the rate of replacement of bulls (α). Therefore, male slaughter in $t + \lambda$ can be expressed as

$$MS_{t+\lambda} = [MB_t(1 - m_t^*)(1 - m_t)^{\lambda-1}]/(1 + \alpha), \quad (60)$$

from which is derived

$$MB_t = [MS_{t+\lambda}(1 + \alpha)]/[(1 - m_t)^{\lambda-1}]. \quad (61)$$

Since female births are approximately 52 percent of births, female births in period t (FB_t) are

$$FB_t = 0.92 MB_t. \quad (62)$$

The stock of male animals of each age at the end of period t is equal to the stock of animals at the end of period $t - 1$ multiplied by one minus the death rate in period t for that age category. When necessary, slaughter is deducted. Thus, the stock of male animals under a year of age in period t ($MH1_t$) is given by the births in year $t - 1$ minus the deaths that take place in year t , or

$$MH1_t = MB_{t-1}(1 - m_t^*). \quad (63)$$

The stock of male animals older than one year and younger than two years at the end of period t ($MH2_t$) is equal to the stock of male animals under one year in period $t - 1$ minus their deaths during year t . That is,

$$MH2_t = MH1_{t-1}(1 - m_t). \quad (64)$$

Finally the stock of male animals older than two years at the end of period t ($MH3_t$) is given by

$$MH3_t = MH3_{t-1}(1 - m_t) + MH2_{t-1}(1 - m_t) - MS_t. \quad (65)$$

The total stock of male animals at the end of period t , MH_t , is given by

$$MH_t = MH1_t + MH2_t + MH3_t. \quad (66)$$

⁶⁶ See Rivas and Valdés, "Variaciones de las Existencias de Ventas de Ganado."

For females, the procedure followed is the same. Thus, letting $FH1_t$, $FH2_t$, $FH3_t$ stand, respectively, for female herd younger than one year, between one and two years, and two and three years of age at the end of period t , then

$$FH1_t = FB_{t-1}(1 - m_t^*), \quad (67)$$

$$FH2_t = FH1_t(1 - m_t), \text{ and} \quad (68)$$

$$FH3_t = FH2_t(1 - m_t). \quad (69)$$

The herd of female animals older than three years is calculated from the total number of births and slaughter as

$$FH4_t = [(MB_t + FB_t)(1 - m_t)]/N_t - FS_t, \quad (70)$$

where N_t is the birth rate and FS_t is female slaughter during year t . The reader should note that it has been assumed that slaughter comes from the categories of males older than two years and females older than three years. Total female herd and total herd at the end of period t are given by

$$FH_t = FH1_t + FH2_t + FH3_t + FH4_t, \text{ and} \quad (71)$$

$$TH_t = MH_t + FH_t. \quad (72)$$

The birth and death rates are calculated as

$$N_t = 0.40 + 0.0756 \log_{10} t, \quad (73)$$

$$m_t = 0.05 - 0.00756 \log_{10} t, \text{ and} \quad (74)$$

$$m_t^* = 0.12 - 0.03025 \log_{10} t. \quad (75)$$

The choice of these functions is based on empirical evidence about birth and death rates for two benchmark years, 1940 and 1960.⁶⁷ Thus, N_{1940} , m_{1940} , and m_{1940}^* are equal to 0.40, 0.05, and 0.12, respectively; and N_{1960} , m_{1960} , and m_{1960}^* are equal to 0.50, 0.04, and 0.08.

With respect to the other parameters, α and λ , it is assumed that the rate of replacement for bulls (α) is 2 percent per year and the average age of male slaughter is five years for the 1940-66 period and four years for the 1967-75 period.

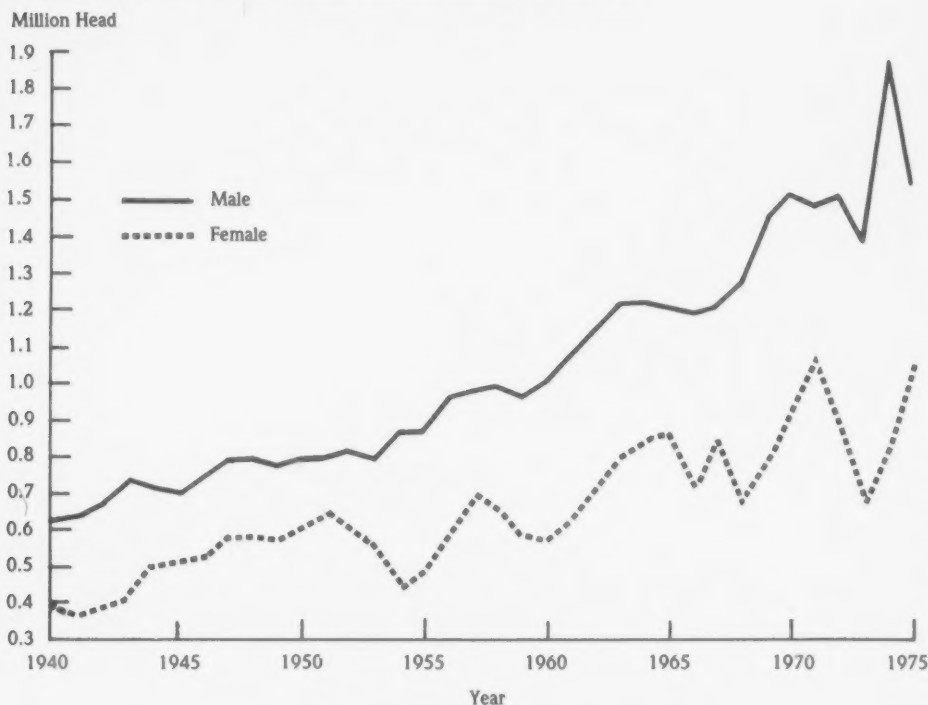
The figures for male slaughter correspond to those for official or registered slaughter. Total slaughter figures incorporate exports of live animals as well as slaughtered animals. As long as illegal exports and nonregistered slaughter occur, the data for births and stocks will be underestimated. Because it is impossible to determine the size of this

⁶⁷ Ibid. The reader will find a more detailed explanation for the selection of these two functions in the paper by Rivas and Valdés.

unregistered activity, it is better to err on the low side.⁶⁸ Thus, these assumptions tend to underestimate the total cattle herd of Colombia for any given year.

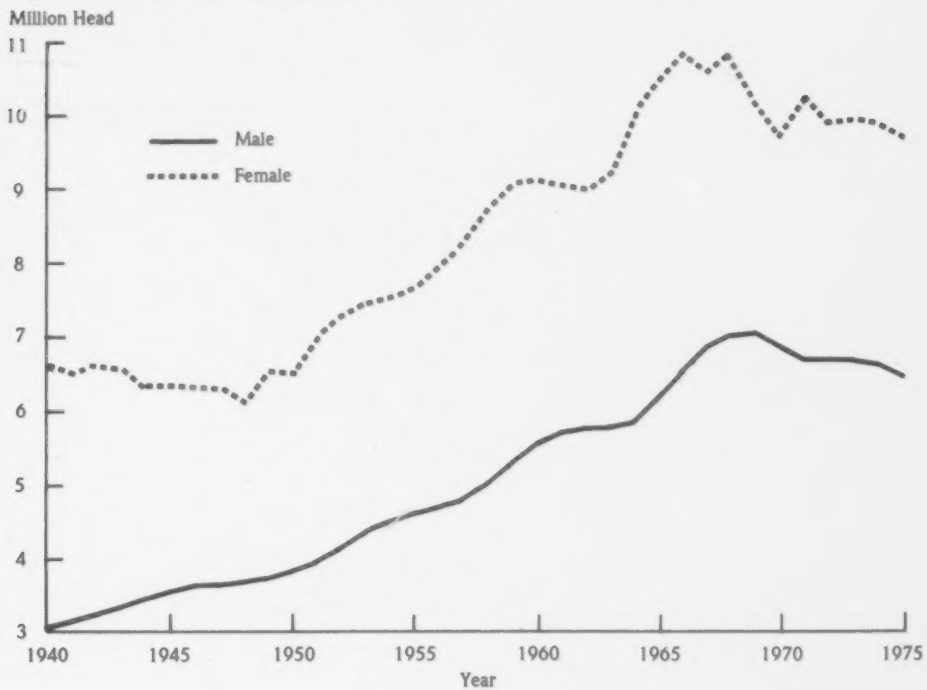
The behavior of sales (slaughter plus exports) and the stock of animals by male and female categories from 1940 to 1975 are shown in Figures 7 and 8. It can be seen that sales increased steadily while the herd experienced substantial increases during the 1950s and 1960s; in the 1970s the size of the herd began to decline, although sales were still rising.

Figure 7—Sales of male and female cattle, 1940-75



⁶⁸ Kalmanovitz's data are perhaps the first attempt to build an annual series for Colombian cattle stock, but his series suffer from serious shortcomings. He assumes that nonregistered slaughter is 10 percent of registered slaughter, without offering a justification for his choice of this value. His figures for illegal exports vary arbitrarily from year to year without sound economic reasons being given for such changes. Death and birth rates also vary arbitrarily from year to year, sometimes by large percentages. The birthrate is half the one used in this study, and he assumes the same death rate for calves and mature animals, which is clearly in contradiction with the evidence. See Salomon Kalmanovitz, *Desarrollo de la Agricultura en Colombia* (Bogotá: Editorial la Carrera, 1978), pp. 121-136. The estimates in this report are closer to those presented by Luis A. Vasquez, "Comercio Exterior de Ganado y Carne en Colombia," in *Primer Foro Nacional Ganadero* (Bogotá: FADEGAN, 1978), Tables 2 and 3.

Figure 8—Size of male and female cattle herd, 1940-75



APPENDIX 3: SUPPLEMENTARY TABLES

Table 29—Value-added and labor income by categories of importable, exportable, and nontraded sectors, 1970-82

Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	(P million 1970)												
Real value added													
Importables	40,098	43,766	48,012	49,745	54,652	54,490	56,749	69,531	73,000	76,512	71,829	72,802	78,536
Exportables	100,701	105,133	115,992	124,051	128,340	130,664	135,420	129,407	142,202	151,289	161,545	162,741	152,806
Coffee	19,326	18,949	19,943	20,232	20,736	22,724	21,126	20,745	27,352	32,306	33,180	32,147	30,980
Noncoffee	81,375	86,184	96,049	103,819	107,604	107,940	114,294	108,662	114,850	118,984	128,365	130,595	121,826
Noncoffee tradable	121,472	129,950	144,061	153,564	162,256	162,429	171,043	178,193	187,940	195,496	200,194	203,396	200,362
Nontradables	160,492	173,279	183,862	197,939	210,374	218,794	229,812	241,274	258,740	270,715	284,863	296,595	305,448
Total	301,291	322,177	347,866	371,735	393,365	403,948	421,981	440,212	474,032	498,516	518,237	532,138	536,791
Labor income													
Importables	15,560	17,271	18,242	18,035	17,668	19,347	20,155	24,693	27,767	30,118	30,833	31,790	35,004
Exportables	32,599	34,671	37,404	37,716	39,416	40,824	41,799	40,669	51,720	58,307	60,068	65,775	60,444
Coffee	3,747	3,563	3,679	3,210	3,741	3,508	3,039	3,602	6,274	8,848	8,464	11,978	10,171
Noncoffee	28,814	30,685	33,484	34,855	35,364	37,316	40,817	40,101	46,969	49,517	51,523	53,488	49,639
Nontradables	71,573	78,874	83,280	86,212	88,154	92,463	94,984	101,849	117,706	127,348	136,046	146,113	151,055
Total	113,575	121,589	131,289	138,448	145,578	152,635	162,812	172,206	189,097	199,701	215,710	220,839	225,157
Labor income													
Importables	6,737	8,092	9,440	11,562	15,114	19,347	24,662	35,381	47,691	64,691	77,243	100,578	136,895
Exportables	13,921	16,067	20,023	24,656	31,400	40,824	55,813	73,986	101,175	133,425	183,735	228,609	269,701
Coffee	1,581	1,432	1,824	2,303	2,679	3,508	5,910	11,455	16,079	20,501	25,451	30,782	33,659
Noncoffee	12,339	14,636	18,199	22,353	28,721	37,316	49,903	62,531	85,095	112,924	158,284	197,828	236,041
Nontradables	30,762	37,395	44,540	55,283	72,879	92,463	116,160	153,789	208,939	283,805	390,274	512,440	668,298
Total	51,420	61,554	74,002	91,501	119,392	152,634	196,635	263,157	357,804	481,920	651,251	841,628	1,074,894

Source: Derived from Colombia, Departamento Administrativo Nacional de Estadística, *Cuentas Nacionales de Colombia, 1970-1983* (Bogotá: DANE, 1984); and working sheets for 1970-83 provided by DANE, División de Cuentas Nacionales.

Table 30—Index of prices of gross value of output relative to prices of nontraded output, 1970-83

Category	1970	1971	1972	1973	1974	1976	1977	1978	1979	1980	1981	1982	1983
	(1975 = 100)												
Relative price of tradables	95.00	92.21	93.98	98.83	102.49	106.17	109.23	103.20	97.54	100.20	96.14	95.46	95.40
Noncoffee tradables	93.06	92.14	93.09	96.79	102.39	101.36	100.72	97.70	95.61	98.99	97.71	97.04	97.38
Imports	96.07	92.38	90.52	95.80	103.78	100.88	100.48	97.75	96.12	96.89	98.32	95.25	95.29
Exports	94.45	92.12	95.83	100.44	101.75	109.00	114.89	106.67	98.42	102.11	94.87	95.60	95.49
Coffee exportables	109.78	92.82	101.69	117.34	103.40	152.60	201.83	149.06	111.67	108.91	83.86	83.02	81.05
Noncoffee exportables	91.20	91.99	94.73	97.42	101.46	101.65	100.90	97.65	95.21	100.50	97.27	98.55	99.45
Agricultural noncoffee exportables	81.73	81.52	87.95	97.86	110.02	101.76	109.94	102.14	94.26	93.23	89.35	88.88	90.07
Agricultural tradables	94.64	87.46	93.52	105.61	106.93	119.10	138.22	118.05	100.33	98.74	86.73	86.10	85.98
Agricultural noncoffee tradables	85.45	84.37	89.09	99.21	108.78	101.50	107.13	98.11	92.05	91.49	88.59	88.03	89.26
Nonagricultural exportables	94.38	95.41	97.00	97.27	98.64	101.62	98.09	96.25	95.51	102.83	99.87	101.94	102.94

Sources: Derived from Colombia, Departamento Administrativo Nacional de Estadística (DANE), *Cuentas Nacionales de Colombia, 1970-1983* (Bogotá: DANE, 1984); and worksheets provided by DANE, Division de Cuentas Nacionales.

Note: For an explanation of the derivation of these data, see Appendix 1.

Table 31—Index of wages, 1967-83

Year	Nominal Wages			Real Wages: Unit Cost of Labor		
	Manufac- turing	Agri- culture	Con- struction	Manufac- turing	Agri- culture	Con- struction
	(1975 = 100)					
1967	32.22	30.43	20.04	99.07	91.95	60.54
1968	34.77	32.29	23.62	101.27	89.21	65.25
1969	39.34	37.18	28.17	106.04	94.96	71.93
1970	46.05	39.72	34.63	113.35	91.99	80.21
1971	51.87	44.41	42.62	115.58	92.83	89.08
1972	59.08	49.98	47.32	116.05	92.47	87.55
1973	66.08	60.01	58.92	106.80	92.39	90.73
1974	81.01	83.95	77.76	98.27	103.10	95.49
1976	126.49	114.61	93.31	105.34	91.36	78.36
1977	160.70	175.69	125.65	107.43	108.43	77.54
1978	218.86	227.67	164.07	122.97	119.99	86.47
1979	273.53	285.14	221.52	123.20	121.16	94.12
1980	354.41	366.54	281.62	123.86	122.04	93.76
1981	456.87	457.22	360.63	129.56	124.00	97.81
1982	624.25	528.57	450.06	140.36	114.89	97.83
1983	767.83	630.31	551.91	n.a.	112.63	98.63

Sources: Derived from Colombia, Departamento Administrativo Nacional de Estadística, *Encuesta Manufacturera*, various issues; Sociedad de Agricultores de Colombia, *Revista Nacional de Agricultura Separata*, 867 (June 1984).

Note: For an explanation of the derivation of these data, see Appendix 1.

Table 32—Population, employment by sector, economically active population, and rate of unemployment, 1965-83

Year	Population			Employment			Economically Active Population (EAP)		Unemployment Rate in Urban Sector
	Rural	Urban	Total	Agriculture	Urban	Total	Total	Urban	
	(1,000 persons)						(percent)		
1965	8,806.7	9,926.4	18,733.1	2,622.6	2,600.2	5,222.8	5,520.2	2,897.6	10
1966	8,885.7	10,377.0	19,262.7	2,643.5	2,718.3	5,361.8	5,698.5	3,055.0	11
1967	8,962.4	10,831.7	19,794.1	2,663.6	2,820.1	5,483.7	5,879.6	3,216.0	12
1968	9,042.2	11,286.5	20,328.7	2,684.6	2,977.8	5,662.4	6,063.8	3,379.2	12
1969	9,117.2	11,734.6	20,851.8	2,705.1	3,165.0	5,870.1	6,248.9	3,543.8	11
1970	9,184.6	12,179.5	21,364.1	2,722.4	3,340.4	6,062.8	6,431.0	3,708.6	10
1971	9,242.1	12,622.9	21,865.0	2,736.6	3,491.1	6,227.7	6,613.1	3,876.5	10
1972	9,290.9	13,062.8	22,353.7	2,748.3	3,666.9	6,415.2	6,793.8	4,045.5	9
1973	9,332.3	13,497.7	22,830.0	2,757.7	3,720.1	6,477.8	6,973.0	4,215.3	12
1974	9,378.0	13,895.0	23,273.0	2,789.9	3,866.7	6,656.6	7,165.5	4,375.6	12
1975	9,421.0	14,303.0	23,724.0	2,821.6	4,136.7	6,958.3	7,480.1	4,658.5	11
1976	9,462.0	14,723.0	24,185.0	2,852.8	4,432.4	7,285.2	7,799.7	4,946.9	10
1977	9,498.0	15,156.0	24,654.0	2,883.6	4,676.0	7,559.6	8,047.2	5,163.6	9
1978	9,530.0	15,602.0	25,132.0	2,912.4	4,992.6	7,905.0	8,345.0	5,432.6	8
1979	9,560.0	16,060.0	25,620.0	2,941.6	5,246.7	8,188.3	8,713.6	5,772.0	9
1980	9,585.0	16,532.0	26,117.0	2,969.5	5,570.6	8,540.1	9,159.0	6,189.5	10
1981	9,605.0	17,018.0	26,623.0	2,995.8	5,671.2	8,667.0	9,207.4	6,211.6	9
1982	9,622.0	17,518.0	27,140.0	3,021.3	5,904.3	8,925.6	9,531.0	6,509.7	9
1983	9,633.0	18,033.0	27,666.0	3,045.0	6,039.3	9,084.3	9,830.8	6,785.8	11

Sources: Corporación Centro Regional de Población, "Área Socio-Económica: Modelo de Corto Plazo," unpublished data.

Notes: Rate of unemployment is derived from the following equation:

$$(\text{Total employment} - \text{Agricultural employment}) / (\text{EAP} - \text{Agricultural employment}).$$

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Shubh K. Kumar
David Hotchkiss

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FOREWORD

In the face of growing concerns about the environment, policymakers in developing countries find themselves increasingly pressured to choose between environmental deterioration in the long run and the growing demands of poor populations in the short run. Some environmentalists point to new technology—irrigation, fertilizer, and pesticides—as the basis of ecological decay in rural areas. A number of studies have shown, instead, that expanding farm yields in less fragile areas through modern technology offers a viable alternative to stripping the land to expand crop area in marginal soils.

In the hill areas of Nepal, as in many developing countries, women's work is the key not only to the functioning of the household but also as a necessary supply of field labor. In *Consequences of Deforestation for Women's Time Allocation, Agricultural Production, and Nutrition in Hill Areas of Nepal*, Research Report 69, Shubh K. Kumar and David Hotchkiss show that the allocation of women's time, as affected by deforestation, has far-reaching effects on farm output, income, and nutrition. In countries such as Nepal, where adoption of modern agricultural technology is so low, it seems that the environment, agriculture, and the quality of life all suffer for this state of affairs.

John W. Mellor

Washington, D.C.
October 1988

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Shubh K. Kumar
David Hotchkiss

SUMMARY

The hill areas of Nepal are a prime example of an area in which low-productivity agriculture is surrounded by rapid environmental degradation as the result of deforestation, and the interaction of the two is promoting further deterioration in both. The following characteristics prevail in the area: low agricultural productivity; high out-migration; a high reliance on labor input in production, especially given the limited use of agricultural technology; and pressure to expand cultivated land at the cost of forest land as population grows. The literature suggests that even in densely populated hill areas, deforestation does not occur as a result of fuelwood consumption by the local population. Instead, it is the low agricultural productivity and the inability of the existing land to sustain the growing population that puts pressure on forestland. Some estimates suggest that in just over 10 years, from the late 1960s to the early 1980s, up to half of the forests in some hill regions have been cut down, with the area under forest reduced from nearly 60 percent to 30 percent of the total area.

In this report, the cost in time spent collecting fuel is used as a measure of the consequences of deforestation; its effects on time allocation, agricultural output, food consumption, and nutrition are examined. In particular, the allocation of women's time is influenced because women are engaged not only in the collection of fuelwood and other essential forest products affected by deforestation—such as leaf fodder and grass for livestock feed—but also in agricultural production.

According to the study's hypothesis, deforestation reduces agricultural output from existing cultivated land by increasing time spent in collecting essential forest products, which shifts time away from agriculture. As a result, household income from agriculture is reduced. Unless alternative sources of income increase, food consumption and eventually the nutritional status of the population will be adversely affected. Because livestock production is also an important part of household enterprise in these areas, the destruction of forests also influences this sector. A reduction in the availability of fodder used for stall feeding increases the pressure for grazing, which increases soil erosion on lands that are currently not under cultivation. Also, children who are involved in collection and livestock grazing activities may experience adverse effects on health and education, which would ultimately influence the region's prospects for raising the productivity of labor.

The study is based on results from a year-long survey of 120 households in three hill districts of the Western Development Region in Nepal, conducted in 1982/83 jointly with the Agricultural Projects Services Centre of Nepal and the Food and Agriculture Organization of the United Nations. Results indicate that when deforestation—represented by the time required to collect a standard load of firewood—increased by 1.0 percent, there was a reduction in fuelwood consumption of 0.3 percent and an increase in the total time required for its collection of 0.6 percent. Assuming a similar response for other essential forest products, the collection time for fuelwood, leaf fodder, and grass alone required an additional 1.13 hours per day by women in the high deforestation sites in the sample. This represents a 45 percent increase, assuming that all workers engaged in the activity increase their work in proportion to their earlier input. The effects of this on the amount of labor available for agriculture indicate that women's

farm labor would decrease by 1.4 hours per person per day, or nearly 50 percent. This decrease is not compensated for by an increase in wage labor or by men's labor, which may also decrease.

Analysis of the production functions for cropping activities indicates that women spend the most time on the dry-season crops—wheat, maize, and mustard. But the time spent for collection of fuelwood is also greater during the dry season because that is when people collect extra amounts of wood and store it for later use. As may be expected, the marginal product of upland crops—maize and ragi—is about half that for the lowland crops—paddy, wheat, and early paddy.

Caloric availability and the ratio of kilocalories from rice compared with other cereals are positively influenced by the component of household income that comes from agriculture and time spent on food preparation and cooking. At the same time, food preparation time is positively associated with the amount of fuelwood used and negatively with the amount of total time spent in fuel collection. This suggests that in addition to the effects of deforestation on agricultural production and incomes, secondary or associated effects could be related to fuel consumption and time spent on food preparation. The main determinants of preschool child nutrition are degree of deforestation, household income, household size, and work loads of women and older children. In addition, the data indicate that the Tibeto-Burman ethnic groups have better child nutrition than the Newar-Brahmin groups, when the influences of other household characteristics are controlled for.

The results suggest that it is not enough to rely on out-migration or reforestation efforts alone to improve the economy and ecology of the region. (One out of every two households already has a permanent migrant worker.) Strategies for raising agricultural productivity need to be considered. In the long run, agricultural products that offer high value to weight, such as horticultural products, may be a feasible proposition for the region. This requires investments in research and extension, as well as an efficient marketing system suited to the primarily smallholder agriculture. At present, production is largely subsistence-oriented and not very productive; therefore, the degree of rural market development is limited. In the short run, therefore, it appears necessary to increase productivity of the traditional crops through the use of improved technologies that already exist and can be promoted, thus shifting away from subsistence production and promoting the growth of rural market infrastructure.

This could provide the base for a gradual shift into more specialized horticultural and livestock products. In order to achieve this, efforts will be needed, first, to promote improved input use, and, second, to alleviate human labor bottlenecks for both small and larger farms. Labor-saving technologies for nonfarm activities, such as food processing and water supply, should also be included. Agroforestry programs that reduce collection time for essential forest products would also complement such an agricultural intensification effort in the hills of Nepal.

INTRODUCTION

Agricultural strategies for areas of low or marginal potential have been receiving increased attention recently.¹ This concern has been driven by several factors. Sustainability of agricultural growth requires a constantly expanding frontier beyond the areas currently experiencing rapid growth. Also, growing regional inequity between rural areas where rapid agricultural growth is occurring and those left behind is sometimes pointed to as an undesirable feature of improved agricultural technologies.² Related to both is concern for deterioration of the environment, which usually stems from the effects of excessive growth in input use in intensively cropped areas, but increasingly also from rampant environmental degradation, including deforestation, in areas where growth is stagnant.³ All of these concerns point to the need for a closer examination of production characteristics and constraints to growth in the so-called low potential areas, so as to identify the best strategy for incorporating them into the overall development picture. In Nepal the major focus for agricultural development efforts has been in the southern plains, the tarai. In the hill areas the focus has been on reforestation and soil conservation efforts, and agricultural growth incentives have been virtually nonexistent.

In analyzing the range of situations that arise in the association between labor input and agricultural output in developing countries, two main groups or types have been identified. According to John Mellor,⁴ they can be classified as, first, the labor-surplus case, in which highly productive nonhuman agricultural resources initially provide food for more people than are needed to work on the land, eventually leading to a large pool of underemployed and surplus labor. In such areas, there is a good potential for widespread adoption of labor-intensive agricultural technologies and for growth in rural off-farm employment. Second is the "hardworking-peasant" case, in which output is directly a product of labor input.

The first of these two situations represents most of the high-growth agricultural areas of Asia and Latin America, while the latter is generally prevalent in African agriculture. Semi-arid and hill areas in Asia, however, may also be cast in the hardworking-peasant mold.⁵ Since the marginal product of labor is higher in the latter situation, labor constraints are more likely to develop, but it is difficult to support additional labor, when aggregate productivity is low. The significance of human labor in agricultural

¹ Consultative Group on International Agricultural Research, Technical Advisory Committee, *Sustainable Agricultural Production: Implications for International Agricultural Research* (Rome: Food and Agriculture Organization of the United Nations, TAC Secretariat, 1987).

² Irma Adelman, "A Poverty-Focused Approach to Development Policy," in *Development Strategies Reconsidered*, ed. John P. Lewis and Valeriana Kallab (Washington, D.C.: Overseas Development Council, 1986), pp. 49-65.

³ World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987).

⁴ John W. Mellor, "Determinants of Rural Poverty: The Dynamics of Production, Technology, and Price," in *Agricultural Change and Rural Poverty: Variations on a Theme by Dharm Narain*, ed. John W. Mellor and Gunvant M. Desai (New Delhi: Oxford University Press, and Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute, 1986), pp. 21-40.

⁵ Ibid.

production remains high. Moreover, it is precisely from such areas that there is high out-migration of labor because of the relatively low productivity of the land. As the population grows, pressure to expand cultivated area is also high. This promotes deforestation and progressively lowers agricultural productivity.

What are the development policy implications for such regions? One approach that has been favored by many is that of benign neglect or of encouraging migration from these areas. Another focuses on fostering high-value cash crop production, such as horticulture and tree crops. This approach can be viable if institutional and infrastructural developments support the production, and especially the marketing, of these products. A parallel approach that is receiving increasing attention in this context is agroforestry development. Forests contribute a wide range of products essential to household production and survival, but they also contribute to the long-term environmental and agricultural land quality of the region. Growing trees as a crop can, over the course of years, contribute to household agricultural production and income generation. In the short run, however, tree crops may compete for land on which food is grown. It is possible that this competition may be reduced by raising agricultural productivity, thereby reducing the dual pressure on existing forestland for fuelwood and for land for cultivation.

Improving agricultural performance requires choosing an appropriate mix of inputs and technologies. Hence it is expeditious to examine the characteristics of producer households and to identify their relevant constraints. This provides the basis for appropriate policies to supplement market forces in providing the impetus for change.

Significance of Human Labor in Traditional Agriculture

In general, it may be useful to consider the issues of poverty, low labor productivity, and the environmental consequences together. Environmental degradation, whether it is due to excessive livestock grazing or deforestation, is largely in response to strategies for providing for human energy needs. However, as a consequence of the destruction of environmental resources, the human cost of using these resources also increases. Where productivity is low and the reliance on human labor is high to begin with, this loss of environmental resources is likely to further reduce agricultural productivity.

Traditional agriculture is characterized by a high proportion of human labor input and low productivity of land and labor. When the total amount of energy that goes into farming is calculated, it appears that subsistence farming actually requires more energy resources per hectare, especially per ton of food output, than technologically advanced forms of agriculture. However, when the concept of "useful energy" is applied—that is, energy actually delivered or made available for the production process to occur (through land preparation, irrigation, fertilizer application, and so forth)—then the picture is reversed.⁶ Increases in useful energy input via irrigation, application of manure and fertilizer, improved management practices, or improvement of plant efficiencies through breeding provide the main mechanisms for achieving higher yields.

While it may seem that these observations really just state the obvious, the useful energy concept does serve to highlight the importance of human energy input and labor constraints in subsistence agriculture, as represented by the hardworking peasant mentioned earlier. An increase in useful energy input in Third World agriculture has

⁶ Arjun Makhijani, *Energy and Agriculture in the Third World: A Report to the Energy Project of the Ford Foundation* (Cambridge, Mass.: Ballinger, 1975).

also been found to increase the intensity of labor use per hectare, even as the share of human energy input in production declines.⁷ These empirical observations are fully consistent with the theoretical expectations for labor input and productivity in high- and low-productive agriculture, with the theory that labor demand increases with technological change, and with the nutrition-wage hypothesis.⁸

Human labor input is required both for the production of crops and the household's provision of its nonfarm energy supply that comes primarily from forests, providing essential fuel and animal feed products. As long as both crop and noncrop energy supplies for human consumption remain heavily dependent on human labor, labor productivity remains low, yet the marginal product of labor remains relatively high.⁹ Land under crop production competes with forestland. This competition is further accentuated by increasing population pressure. In an eastern hill area of Nepal, Bajracharya documented that the forest fuel supply was adequate to meet people's needs, but arable area could not meet their food needs.¹⁰ He concludes that it is essential to increase productivity of land if farmland encroachment on forests is to be reduced and a sustainable agricultural economy attained. If this does not occur, forest resources will become increasingly scarce, further accentuating the requirement for human labor and creating a further downward pressure on the productivity of land.

Quality of human labor input may also be adversely affected if low land productivity, combined with heavy demand for human energy expenditure for both crop production and provision of noncrop energy, impairs the nutritional status of the workers. Both chronic and acute food scarcities limit human work capacity, and again it is necessary to improve agricultural and labor productivity. As noted earlier, these improvements are usually accompanied with some increase in demand for labor. For smallholders of the hardworking-peasant type, this involves an explicit cost, and unless credit is available, it may not be possible to shift labor away from other activities, such as fuel and fodder procurement and essential household maintenance activities. Further, even if expected yields are vastly improved, the inherent riskiness of input adoption in the initial stages could discourage early adoption by smallholders. In order to overcome this obstacle, the public sector initially may need to play a large role in reducing the risks involved in changing resource allocation of farm households. Consequently, investments that reduce a range of household constraints—including labor requirements for noncrop activities, cash, and animal labor constraints—may need to be incorporated. Clearly, the availability of improved agricultural technologies would provide the justification for making these public investments.

In areas where growth in agricultural productivity by smallholders has occurred, it has been found that this is followed by expansion of markets and private investments in both agricultural and supportive nonagricultural sector activities in the area.¹¹ This

⁷ Ibid.

⁸ Uma Lele and John W. Mellor, "Technological Change, Distributive Bias, and Labor Transfer in a Two-Sector Economy," *Oxford Economic Papers* 33 (November 1981): 426-441; and John W. Mellor and Robert D. Stevens, "The Average and Marginal Product of Farm Labor in Underdeveloped Countries," *Journal of Farm Economics* 28 (August 1956): 780-91.

⁹ A comparison of labor production functions for low-productive hilly, dryland areas and high-productive areas was made by Mellor and Stevens in "Average and Marginal Product of Farm Labor."

¹⁰ Deepak Bajracharya, "Fuel, Food, or Forest? Dilemmas in a Nepali Village," *World Development* 11 (No. 12, 1983): 1057-1074.

¹¹ Sudhir Wanmali, *Service Provision and Rural Development: A Study of Miryalguda Taluka*, Research Report 37 (Washington, D.C.: International Food Policy Research Institute, February 1983).

not only helps to ease the pressure on land to provide income and employment growth but also produces a base from which further transformation in the agricultural sector can be more readily obtained. This could include a transition toward horticultural and other high-valued but perishable products to which the hill ecology is suited. This serves to provide an additional justification for judicious public investments to overcome the initial bottlenecks and thus raise agricultural productivity.

Objectives and Rationale

The objectives of this report are to examine the effects of labor constraints, particularly of women's labor, on output from small hill-area farms and the direct adverse consequences of deforestation on such farms. More specifically, the report examines women's time allocation in a poor agricultural area for its effects on agricultural production, food consumption, and the nutritional status of children. It looks at the possible consequences of deforestation for agricultural output, as a result of competing demands for women's labor. It uses the labor costs of fuelwood collection as a measure.

It has been argued that deforestation in hill areas can have adverse consequences for plains agriculture. Flooding and silting, traditionally the source of agricultural potential for plains agriculture, also cause the rapid blockage of irrigation canals. These consequences are quite apart from the widespread ecological and environmental consequences of deforestation. These observations have led to concerted efforts to slow down the rate of forest depletion. Though agroforestry—the incorporation of tree cultivation in household farming—is often promoted as a means of slowing deforestation, the explicit linking of this process with existing agricultural activities in crop and livestock production in these areas is seldom made.

If deforestation leads to reduced agricultural productivity of land, understanding the mechanisms involved would assist in efforts to improve agriculture as well as in the forestry efforts. When yields are too low to sustain the growing population, even with high out-migration, there is inevitably pressure to expand cropland. This is often at the cost of forests. Thus while forestland may provide a safety valve for the growing population in the short run, its depletion only promotes the cycle of declining agricultural productivity.¹² In this study it is argued that productivity of agricultural land would decline, despite new land coming into production, as a result of additional labor demands created by deforestation. The increasing distance from and hence time required to collect essential forest products competes with labor input in agriculture. Therefore, unless measures to improve agricultural productivity are undertaken simultaneously, the push for clearing new land due to population growth will continue.

The focus in this report is on the issue of labor constraints, particularly on women's labor, as an intermediary to the adverse consequences of deforestation. Low productivity agriculture is known to rely heavily on input of human labor.¹³ In areas where women provide most of the labor in the collection of forest products, this labor increases with deforestation. If they also provide labor in agriculture, then the consequences for production depend on their ability to take on more work and the degree of substitution between men's and women's work in agricultural production. These are some of the questions that will be examined.

¹² Bajracharya, "Fuel, Food, or Forest?"

¹³ Mellor, "Determinants of Rural Poverty."

Since women also have the major responsibility for activities directly related to food consumption, such as food processing and preparation, deforestation and increasing work loads could also have a direct effect on this activity, with possible adverse consequences. Similarly, preparing food and feeding young children is time-intensive for women, and direct adverse effects are also possible there. These two effects would be likely to occur over and above any of the changes in food consumption and nutrition engendered by the effects on agricultural productivity.

In the analysis of all forest products used by the local population, only changes in fuelwood consumption and the associated time costs are used to represent the consequences of deforestation. However, other essential forest products, such as leaf fodder and grass and water, can be expected to be influenced in a similar way. Leaf fodder and forest grass are an important part of livestock feeding because they reduce pressure on the limited grazing lands available. With deforestation, there would be either the additional work of collection or increased grazing, with direct effects on livestock production and indirect effects on both agricultural production and food consumption. It is expected that making the explicit connection between patterns of labor allocation, deforestation, and agricultural productivity will help identify the extent to which labor constraints are a factor and hence will suggest alternative approaches for increasing productivity.

GENERAL CHARACTERISTICS OF STUDY AREA AND HOUSEHOLDS

This report presents results obtained from a year-long household survey in a hill area of the Western Development Region in Nepal. The survey consisted of four quarterly rounds of data collection from 120 households using a pretested, structured questionnaire. Information was obtained on agricultural production, collection of forest products, time use patterns for selected activities, expenditures, off-farm employment, migration, and remittances. Food consumption was estimated using the disappearance method for crops, livestock, and horticultural products, together with expenditure data. Anthropometric measurements on all household members were taken at the time of the survey. In order to validate the time allocation measures from the survey, a more detailed time sampling technique was used on a subsample of 12 households.

The survey was conducted by the Agricultural Projects Services Centre (APROSC) of Nepal and the Food and Agriculture Organization of the United Nations (FAO) in 1982/83 with assistance from the International Food Policy Research Institute. Its initial purpose was to help area-level agricultural planners incorporate labor, energy, and nutrition links into the agricultural production process. That exercise was completed in December 1985. This report builds substantially on the work done for that phase.¹⁴

Nepal is divided into three distinct ecological zones, the tarai, a band of lowland plains to the south, high mountains to the north, and the hill areas in the middle (Figure 1). The six wards from which the sample households were chosen were selected from three *panchayats* in hill districts of the Western Development Region. The objective of the sampling was to obtain as wide a representation as possible of the major social, economic, and ecological characteristics of the area. Thus, *panchayats* were selected first and then wards to cover variations in altitude, access to roads and markets, ethnic groups, and degree of deforestation.

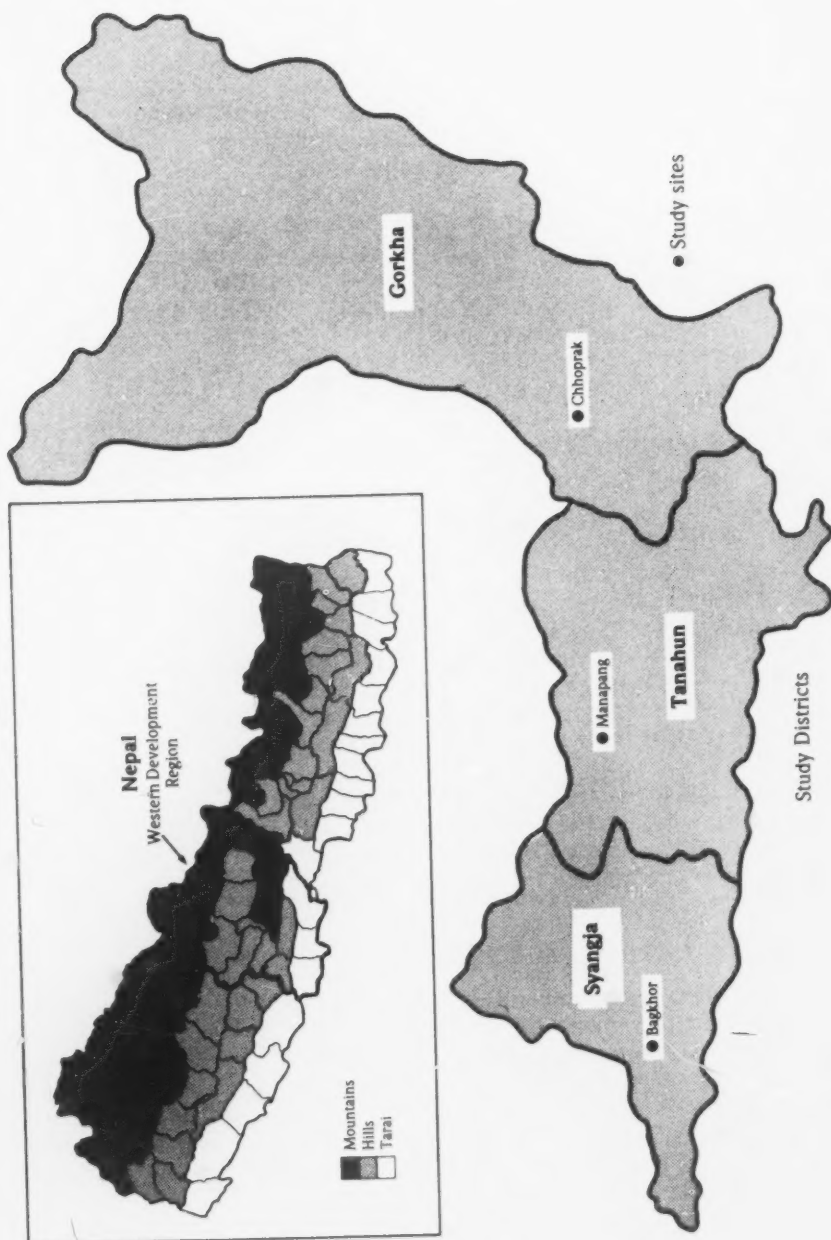
The sites selected were

District	Panchayat	Wards
Gorkha	Chhoprak	1 and 7
Tanahun	Manapang	5 and 8
Syangja	Bagkhor	2 and 8

The hill areas are, naturally, composed of hills (highlands) and valleys (lowlands). The altitudes at which farms are located range from a low of about 500 meters in Manapang to a height of about 1,500 meters in Chhoprak. Road transport and markets are easily accessible in Bagkhor, but they are a day's hike from Chhoprak. While it was not possible to obtain every possible type of situation, the distribution was a fair representation of road and market access at different altitudes. Similarly, the degree of deforestation is most severe in Chhoprak, and less severe in Manapang. In an effort

¹⁴ Shubh K. Kumar and David Hotchkiss, "Energy and Nutrition Links to Agriculture in a Hill Region of Nepal," International Food Policy Research Institute, Washington, D.C., 1985 (mimeographed).

Figure 1—Study area and sites and ecological zones of Nepal



to obtain both lowland and highland agricultural characteristics in each of the selected *panchayats*, a somewhat higher inclusion of lowland farmers relative to what generally prevails in these districts may have resulted. Associated with this was a slightly higher proportion of Brahmin castes in the study source, as they tend to predominate in lowland farming. In the hill areas, lowland, called *khet*, may occur either in valley bottoms or on mountainsides. It is distinguished from upland, called *pakho*, by the fact that it can be irrigated at least during some part of the year. It is expected that this sampling bias may improve the analysis of production constraints for different crops, but it will not influence the results of the deforestation links to agriculture and nutrition. Within these selected wards, a random sample of 20 households (approximately 8 percent of households) was taken from each for a total of 120 households for the survey. A ward census survey was undertaken to assess the characteristics of the sample. A comparison of the basic assets of the households sampled with those in the census survey indicates a close comparability between the two groups.¹⁵

Size and Composition of Households and Landholdings

The average household size was between six and seven members (6.6), with one permanent migrant worker for every two households.¹⁶ The average number of adult women per household was just slightly higher than the number of men. Children below six years of age constituted 20 percent of the total population, and those below 15 years of age were 45 percent of the population. This is consistent with the expected demographic pattern in developing countries.

The average landholding size was 1.45 hectares, of which 0.62 hectare was lowland or *khet*, on which water control is possible, and 0.83 hectare was upland or *pakho*, on which only rainfed agriculture is possible. Comparison with national surveys suggests a somewhat higher average farm size in this study sample than might be expected in the region (Table 1). This is mainly because more lowland was included in the sample, and lowland holdings are generally larger. This table suggests that the effective population density in terms of pressure on arable land may be much greater in the hill regions, even though the population density is lower than in the tarai in terms of population to total area.

Cropping Intensity and Patterns

The average cropping intensity of land is about 150 percent, indicating that half the land is cropped twice. Comparison with estimates made for Nepal as a whole until the late 1970s shows that cropping intensity in the study area is much higher than the national average. Moreover, the cropping intensity is nearly as high for the *pakho* at 142 percent as for the *khet* at 163 percent. This indicates an extremely high degree of cultivation intensity, which is partly a consequence of the effective population pressure on the arable land. A favorable rainfall distribution in the hills relative to the tarai is also likely to be a factor. The high cropping intensity for upland plots is particularly striking and could indicate that the potential for raising agricultural produc-

¹⁵ Food and Agriculture Organization of the United Nations, *Pilot Study on Energy Use and Nutritional Status at Farm Level in the Hills of Nepal*, Report No. 1 (Rome: FAO, 1984).

¹⁶ A permanent migrant worker is one who is away for more than six months at a time.

Table 1—Average size of operated landholdings of sample farm households and Nepal, by region, 1982/83

Region	Operated Holdings		Total
	Lowland	Upland	
	(hectares)		
Study area			
Total sample mean	0.62	0.83	1.45
Nepal			
Hill			
Eastern	0.10	0.96	1.06
Central	0.34	0.82	1.16
Western	0.22	0.45	0.67
Midwestern	0.13	0.37	0.50
Far Western	0.22	0.16	0.38
Hill average	0.20	0.55	0.75
Tarai			
Eastern	1.28	0.74	2.02
Central	1.18	1.03	2.21
Western	0.36	1.64	2.00
Midwestern	2.42	0.58	3.00
Far Western	1.84	2.11	3.95
Tarai average	1.41	1.22	2.63

Source: Nepal, Agricultural Projects Services Center, *Foodgrain Marketing and Price Policy Study* (Kathmandu: APROSC, 1982), p.81; Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

tivity in hill areas is good. This may be even more so in the eastern half of the country where rainfall is relatively abundant.

While rice is the major lowland crop, both maize and ragi (finger millet) have a high share of cropped upland (Table 2). Among the lowland crops in the study area, early paddy production is much more prevalent than might have been expected, and in the upland plots, ragi area is higher than expected. It can be seen from the cropping calendar in Figure 2 that these crops do not displace the other major crops, and they contribute to the high cropping intensity noted earlier. In addition to these crops, small amounts of soybeans are planted along paddy ridges. Fruits and vegetables are grown mainly on homesteads and contribute only about 5 percent of household income. No farmland was reported to be sown with fodder crops.

Crop Yields

Crop yields in the study area are very similar to those for the country as a whole (Table 3). Although cropped area has increased for the country as a whole and for hill areas in particular, yields have declined over time. Between 1975/76 and 1982/83, for example, area under paddy in the hills increased by 30 percent, wheat by 50 percent, and maize by 10 percent. At the same time, yields for paddy declined from 2.6 to 2.0 tons per hectare and maize from 1.8 to 1.4 tons per hectare. Area increases and yield reductions are not so marked in the tarai. The only exception to this is wheat. For this crop, suitable high-yielding varieties (HYVs) have become readily available in the past 10-15 years, which has led to a sharp increase in cropped area for wheat—71.5

Table 2—Cropping pattern in the study area, 1982/83

Crop	Bagkhor		Chhoprak		Manapang		Total
	Ward 2	Ward 8	Ward 1	Ward 7	Ward 5	Ward 8	
	(hectares)						
Lowland crops	0.77	0.35	0.42	1.73	1.10	1.54	0.98
Early paddy	0.04	0.01	0.15	0.41	0.05	0.53	0.20
Paddy	0.33	0.28	0.27	1.11	0.82	0.53	0.55
Maize, irrigated	0.14	0.01	0.00	0.00	0.22	0.04	0.07
Wheat	0.25	0.05	0.00	0.20	0.02	0.45	0.16
Upland crops	0.83	0.83	1.69	1.47	1.36	1.07	1.21
Maize, dry	0.42	0.43	0.73	0.74	0.74	0.34	0.57
Ragi (finger millet)	0.41	0.41	0.70	0.19	0.60	0.16	0.41
Mustard	0.00	0.00	0.13	0.16	0.01	0.04	0.06
Blackgram (legume)	0.00	0.00	0.13	0.38	0.00	0.53	0.18

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

percent compared with 13.7 percent for all cereals between 1970/71 and 1980/81—as well as to increases in yields of as much as 44 percent during the same period.¹⁷

Livestock Ownership

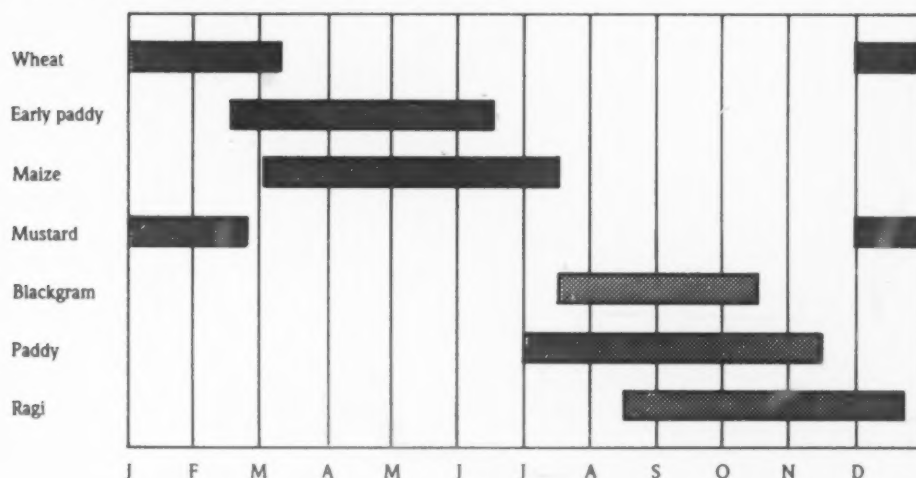
Livestock is an essential component of agricultural production in Nepal. With increasing intensification of crop production, the absolute requirement for animal labor increases, and the timely availability of livestock labor for field preparation becomes more important in maintaining or improving crop yields.

There is a wide variation in the distribution of livestock populations in Nepal. Though figures for the country as a whole are not available, a comparison of the study area with selected districts for which figures are available is given in Table 4. In Nepal as a whole, more livestock is owned in the tarai than in the hills, but livestock ownership in the study area appears to be relatively high for the hills. In addition to inputs for agriculture, livestock and livestock products contribute about 15 percent of household income in the study area.

At the same time that livestock contributes essential labor and products for agriculture, their upkeep entails the use of agricultural by-products such as rice and wheat straw, forest resources for provision of leaf fodder and grass, other feed inputs, and human labor and time. Animals are stall-fed throughout the year, supplemented with grazing in the dry months only. Another important source of animal feed is *kundo*, which consists predominantly of oilseed cake and straw cooked for extended periods of time in water. The making of *kundo* creates additional demand for firewood.

¹⁷ Nepal, Agricultural Projects Services Centre, *Nepal: Foodgrain Marketing and Price Policy Study* (Kathmandu: APROSC, 1982).

Figure 2—Cropping calendar in the study area



Forest Resources

Though an explicit measurement of forest resources in the study area was not undertaken, an estimate for the region indicates that about 22 percent of the area is under forest cover and 50 percent under agriculture.¹⁸ Community forests are largely used for wood and fodder. At the sites where deforestation is most severe, a higher reliance on private trees occurs. These trees are generally planted around the homestead or on the boundary of nearby fields. Although the ownership of private trees for fuel and fodder is considered a necessity by households in such areas, these trees represent only a small proportion of total fuelwood used even there. The present situation indicates that a sharp reduction in forestry resources has occurred since a survey by the Nepal Forest Resource Survey Office published in the early 1970s. In that survey, total area under forests in the hill regions was 55-60 percent, while agricultural area was about 14 percent in the far west, about 30 percent in the central and western hills, and about 36 percent in the eastern hills.

There are several mechanisms by which the gradual reduction in forest cover could have adverse consequences for agricultural productivity. Deforestation contributes to soil erosion, and marginal lands are increasingly brought under cultivation as land becomes deforested. As a result, another set of consequences becomes a factor—the additional demand on family labor to provide essential fuel, fodder, and water for humans and livestock. Usually there is an implicit assumption that there is a surplus of family labor on farms, and the higher labor demands can be easily met. This is the heart of the issue examined in this study. This constraint cannot be measured only in fuel energy or food energy: the limits imposed on time and on total human energy for productive activities as well as for essential consumption activities must also be considered. All have direct implications for human welfare.

¹⁸ Food and Agriculture Organization of the United Nations, *Pilot Study on Energy Use and Nutritional Status*.

Table 3—Yields of principal crops in Nepal, 1975/76-1982/83, and in the study area, 1982/83

Area/Year	Paddy	Maize	Wheat	Barley	Ragi
(metric tons/hectare)					
Nepal					
1975/76	2.07	1.65	1.18	0.93	1.14
1976/77	1.89	1.79	1.04	0.83	1.13
1977/78	1.81	1.66	1.12	0.88	1.07
1978/79	1.85	1.64	1.21	0.85	1.08
1979/80	1.64	1.28	1.20	0.90	0.97
1980/81	1.93	1.63	1.22	0.86	1.00
1981/82	1.98	1.58	1.32	0.86	1.00
1982/83	1.45	1.41	1.36	0.87	0.94
Hill area					
1982/83	1.97	1.43	1.27	0.85	0.95
Study area					
1982/83	1.80	1.20	1.00	...	0.96

Sources: Nepal, Ministry of Agriculture, Department of Food and Agricultural Marketing Services, *Agricultural Statistics of Nepal, 1985* (Kathmandu: MOA, 1985); and Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

In this study an indirect measure of forest resources was used. Since the main consideration was the increase in work load associated with reduced accessibility to forests, it was decided that a measurement of the time spent in collection would be most appropriate. The time for collecting a standard load of fuelwood (about 20 kilograms) was recorded for each household during each quarterly survey. The average time taken

Table 4—Livestock population per household in study area, 1982/83, and in selected districts of Nepal, 1977

District	Bullocks	Cows	Buffalo	Sheep, Goats, and Pigs	Live-stock Units ^a
Study households	1.36	1.75	2.14	3.03	6.93
Selected districts					
Hills					
Ilam	1.65	1.85	1.74	2.41	6.59
Kavre	0.65	2.36	0.42	2.14	4.07
Dhading	0.99	2.15	2.31	2.69	7.14
Syangja	1.02	1.08	2.69	1.14	6.36
Sallyan	1.95	1.74	1.45	2.06	6.28
Kathmandu	0.23	1.69	0.14	1.08	2.35
Tarai					
Chitwan	3.56	3.17	2.67	2.04	11.14
Morang	5.00	2.27	1.00	1.73	9.46
Dhanusha	1.81	0.40	0.74	0.28	3.38
Rupandehi	2.65	0.94	0.99	0.85	5.25
Kailali	4.04	6.02	4.36	4.26	17.45

Sources: For selected districts, Ministry of Agriculture, Department of Food and Agricultural Marketing Services, *Agricultural Statistics of Nepal* (Kathmandu: MOA, 1977); and for study households, Nepal, Agricultural Projects Service Center, the Food and Agriculture Organization of the United Nations and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

^a Buffalo are weighted at 1.5 livestock units, and sheep, goat, and pigs at 0.2.

per unit of fuelwood for each site was then computed and used to indicate the degree of deforestation encountered by the households at that site.

Only fuelwood collection time was used as the indicator for deforestation. Although leaf fodder, grass, and water were also collected, they were not included in the indicator because they are likely to be collected from specific locations. Hence their collection times per unit would be influenced more in a temporal than a cross-sectional way with deforestation. The time required for the household to collect a unit of fuelwood is used here to represent the household's effective distance from the forest area where the bulk of collection occurs. Growing of private trees is too limited to have a significant effect, although households are likely to shift to private trees as deforestation becomes more severe. At the household level, use of time per unit of fuelwood collected is likely to be a better indicator of the opportunity cost (and one that will increase as deforestation increases, given the stable patterns of habitation) than an area-specific measure of forested land.¹⁹

¹⁹ These measures are also extremely difficult to collect and interpret without aerial surveys.

TIME ALLOCATION PATTERNS AND IMPLICATIONS OF DEFORESTATION

How much household time is allocated to production and to production support activities? Production support, or expanded economic activity,²⁰ includes all the activities for collection of fuel, leaf fodder, grass, and water for family and livestock, as well as food processing and cooking. These are essential activities, and a reduction in them without any increase in the productivity of these tasks would entail a real cost to households. The performance of many of the production support activities is affected by deforestation. In the following section, the implications of deforestation for the household are considered from the viewpoint of demand for time to spend on these tasks, as well as possible decreases in the quantity of forest products used. The specific case of fuelwood use is taken as an example to illustrate these changes.

Household Time Allocation

The information on time allocation in this study was obtained by setting up a series of recall instruments geared to the specific activities being measured. Since four quarterly survey rounds were conducted, it was possible to obtain some ideas about the seasonal pattern of time allocation. The main drawbacks were the use of the recall method and the limitation of the recall period to one week for most of the routine collection and food-processing activities. The data collected were then extrapolated to represent a much longer period of three months. In the case of agriculture, recall was by crop following the harvest. Because the recall period here extended over several months, the recall unit was days of work for various activities by crop. Finally, for both agriculture and off-farm employment, an assumption of an eight-hour work day, including travel time, was assumed.

The time allocation data obtained for men, women, and children in Table 5 show that the most intense period for agricultural work is during the rainy-season quarter of July to September. During the dry-season quarter, April to June, less time is spent on agricultural work, but it is the maximum time period for work on production support activities. Fuelwood and water collection activities, in particular, peak at that time of the year. Women's total recorded work time is between 150 and 180 percent of men's recorded work time. Of this total time spent by women, between two-thirds and three-fourths is spent on production support activities. Within the production support category, half to two-thirds of their time is spent on collection tasks alone, or up to half of their total recorded work load. Men spend time equivalent to 50 to 90 percent of their total recorded field work time in agriculture on support activities such as construction, collection, and domestic work. Their maximum time in production support activities, like that of women, is in the dry-season quarter of April to June.

²⁰ The term "production support" is used in the study, *The Status of Women in Nepal*. A summary report of that study is found in Meena Acharya and Lynn Bennett, *The Rural Women of Nepal: An Aggregate Analysis and Summary of Eight Village Studies*, vol. 2, part 9 (Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, 1981).

Table 5—Seasonal pattern of time allocation

Activity	April-June			July-September			October-December			January-March		
	Men	Women	Children ^a	Men	Women	Children	Men	Women	Children	Men	Women	Children
(hours/person/day)												
Agricultural work												
Field work ^b	2.2	2.1	0.1	4.1	3.4	0.0	3.8	3.4	0.0	2.3	2.1	0.1
Employment ^c	0.5	0.2	...	0.6	0.2	...	0.5	0.0	...	1.6	0.1	...
Subtotal	2.7	2.3	0.1	4.7	3.6	0.0	4.3	3.4	0.0	3.9	2.2	0.1
Support activities												
Fuelwood collection	0.4	2.0	0.2	0.0	0.9	0.2	0.0	0.8	0.1	0.1	0.9	0.0
Water collection	0.2	1.6	0.3	0.0	0.9	0.4	0.1	0.9	0.1	0.1	1.2	0.1
Grass collection	1.2	0.9	0.3	0.1	2.4	0.7	0.1	0.4	0.1	0.0	0.2	0.0
Leaf fodder collection	0.1	0.3	0.0	0.0	0.0	0.0	0.2	0.4	0.1	0.1	0.7	0.0
Grazing ^d	...	...	2.5	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	2.6
Food processing	0.2	0.7	...	0.2	0.7	...	0.2	0.7	...	0.2	0.7	...
Cooking	0.4	2.2	...	0.4	2.4	...	0.4	2.1	...	0.3	1.7	...
Subtotal	2.5	7.7	3.3	0.7	7.3	1.3	1.0	5.3	2.5	0.8	5.4	2.7
Total of all recorded activities	5.2	10.0	3.4	5.4	10.9	1.3	5.3	8.7	2.5	4.7	7.6	2.8

Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

^a Children 6-15 years old are included.

^b Fieldwork was recorded by crop, which cuts across individual quarters. Therefore, it is aggregated into two semiannual periods: dry season crops were assigned the first and fourth quarters, and wet-season crops were assigned the second and third quarters.

^c Includes seasonal migration.

^d Since grazing of cattle was mostly performed by children and no data on individual grazing time is available, it is all assigned to that category.

Given the drawbacks in methodology for collection of time allocation information for this study, results were compared with those from the subsample of 12 households, using a more intensive direct observation and time-sampling method,²¹ and with results from the in-depth study on *The Status of Women in Nepal*.²² The methodology used in this study was identical to that used for the subsample.

The results obtained with the structured recall method and with direct observation are remarkably similar. The comparison with *The Status of Women in Nepal* study also shows similar results (Table 6). This table indicates the amount of time spent on activities not enumerated in the present study but picked up by the more comprehensive methodology. It amounts to an additional 20-25 percent of work time by men and children and just over 30 percent more for women. This suggests that the percentage of underreported time in this study due to omitted activities was similar for men, women, and children.

Given the difference in methodologies used in the two studies, the similarity of results is somewhat unexpected. This may be because the respondents in *The Status of Women in Nepal* study were asked to recall the amount of time required to perform a task rather than time allocation per se as in the structured questionnaire used in the

Table 6—Comparison of data on patterns of time allocation from two studies

Activity	Rural Women of Nepal Study ^a			Nepal Energy and Nutrition Survey		
	Men	Women	Children	Men	Women	Children
	(hours/person/day)					
Agricultural work						
Household farm	2.73	2.74	0.99	3.10	2.75	0.05
Employment	1.24	0.46	0.21	0.80	0.13	...
Subtotal	3.97	3.20	1.20	3.90	2.88	0.05
Support activities						
Fuelwood collection	0.24	0.38	0.20	0.13	1.15	0.13
Water collection	0.07	0.67	0.33	0.10	1.15	0.23
Grass collection				0.35	0.98	0.28
Leaf fodder collection	1.43	0.97	1.79	0.10	0.35	0.00
Grazing				(0.90) ^b	...	1.80
						(0.90) ^b
Food processing	0.18	0.97	0.16	0.20	0.70	...
Cooking	0.27	2.05	0.24	0.38	2.10	...
Subtotal	2.19	5.04	2.72	1.26	6.43	2.44
				(2.16) ^b		(1.54) ^b
Total	6.16	8.24	3.92	5.16	9.31	2.49
				(6.06) ^b		(1.59) ^b
Other ^c	1.37	2.57	0.69	n.a.	n.a.	n.a.

Sources: Meena Acharya and Lynn Bennett, *The Rural Women of Nepal: An Aggregate Analysis and Summary of Eight Village Studies*, vol. 2, part 9 (Kathmandu: Tribhuvan University, 1981); and Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: The ellipses indicate a nil or negligible amount. n.a. means not available.

^a Based on observations from five hill villages and one tarai village.

^b The numbers in parentheses are alternate assumptions of cattle grazing time. Under the first assumption all grazing time is assigned to children.

^c Activities recorded by Acharya and Bennett but not included in the present study are manufacturing, hunting and gathering, house construction, plastering walls, cleaning and laundry, shopping, child care, and other domestic work.

²¹ The methodology is derived from Acharya and Bennett, *Rural Women of Nepal*, pp. 16-19.

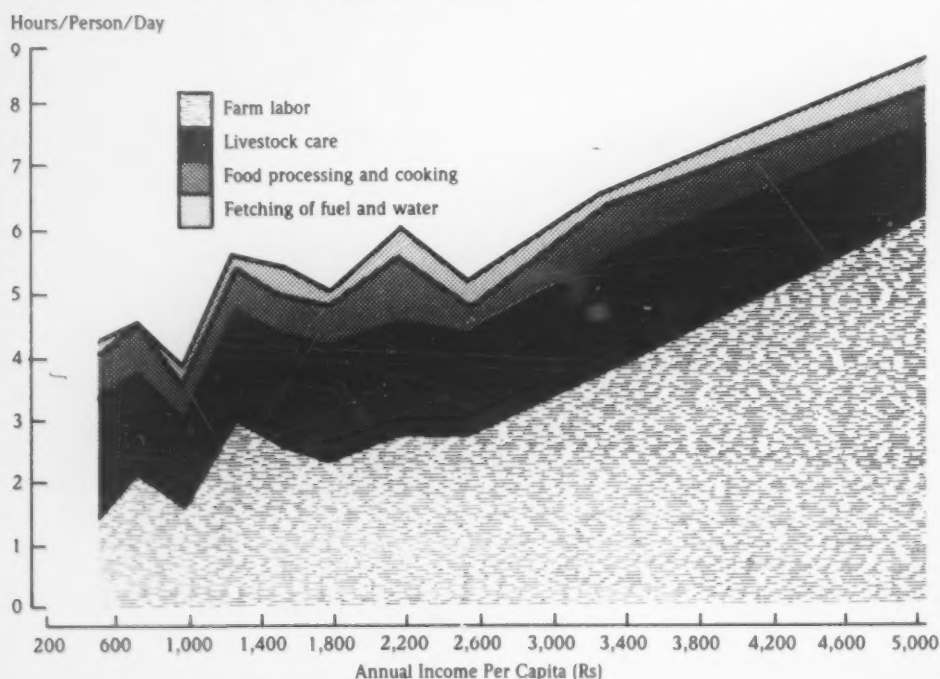
²² Acharya and Bennett, *Rural Women of Nepal*.

present study, which requires a higher degree of knowledge about practices in the area than is usually available for designing survey instruments.

An examination of the effects of household income on men's and women's work time shows that agricultural work increases for both sexes, but especially for men, as household income increases. This may indicate some labor surplus for men at lower income levels, which may be taken up by an increase in seasonal migration. Women's labor, especially their total work load, is less variable by income. This suggests that women are already working long hours at low incomes (and lower food availability). If there is limited substitutability between men's and women's labor in agriculture, then this could curtail men's labor use until it is possible to expand hired labor use. Also, part of the increase in both men's and women's labor with higher income may be due to improved food availability and intakes. Since household income is mainly the product of agriculture and farm size, household labor use seems to increase with farm size. This is confirmed later in the analysis of household labor use.

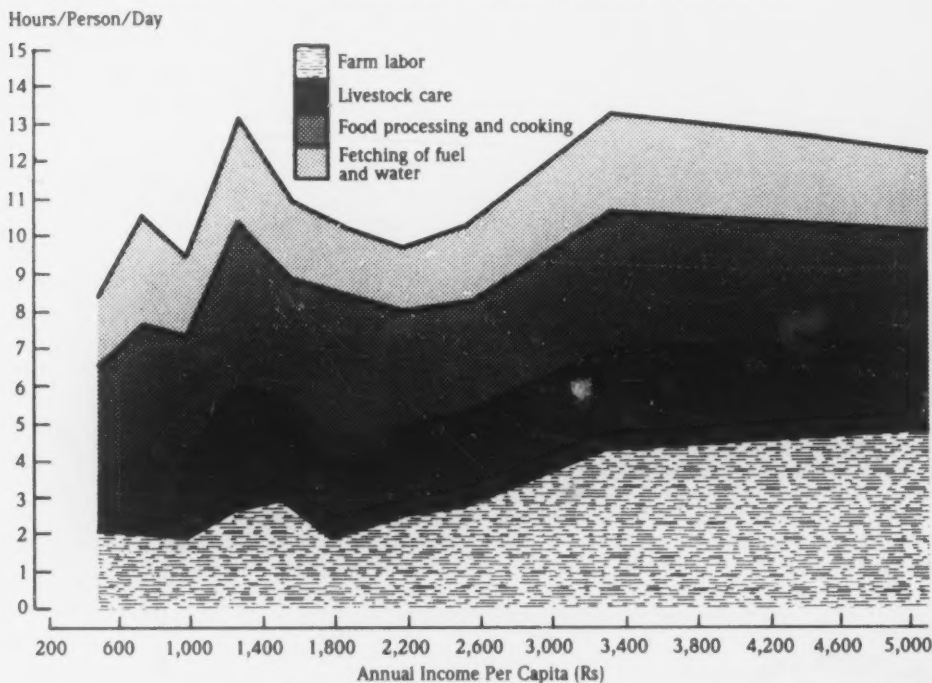
Time spent on other activities is relatively constant at all income levels for both men and women (Figures 3 and 4). This indicates that there is probably a high propensity to spend additional time on agriculture, despite an increase in wage labor use at the higher income levels. This observation, in conjunction with the high marginal product of labor in crop production, as seen later, suggests that if mechanisms were available

Figure 3—Men's time allocation by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Figure 4—Women's time allocation by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

to reduce the time spent on production support activities, more time would be spent on agriculture.

Implications of Deforestation

As deforestation proceeds, access to forest resources becomes more and more removed for the settled population. In the long run, populations have been observed to shift increasingly to other sources to substitute for these fast-depleting resources. Fuelwood is increasingly replaced by straw and dungcakes or other by-products. (At the time of this study, cow dung was used exclusively for manuring fields and not as fuel.) Leaf fodder and grass for animals are replaced by increased grazing,²³ coarse grains, and crop by-products. Also in the long run, water from forest streams becomes more scarce and is replaced by water from more distant or contaminated rivers and

²³ This is shown to have occurred in India in Subhachari Dasgupta and Asok Kumar Maiti, *The Rural Energy Crisis, Poverty, and Women's Roles in Five Indian Villages* (Geneva: International Labour Organisation, Rural Employment Policy Research Programme, 1986).

ponds. All of these changes have adverse effects on productivity and health, which can partly be alleviated by higher incomes and the ability to purchase the alternatives in the marketplace. However, if aggregate productivity of agriculture is also declining, then the possibility of higher incomes also declines.

In order to understand the wider implications of household responses, the starting point for this analysis is the behavioral response of deforestation on fuelwood consumption behavior. Fuelwood demand is expected to be influenced by both income and price factors, as well as fixed demand factors such as family size. Livestock numbers also influence fuel consumption in Nepal because livestock are fed a cooked feed preparation called *kundo* to increase the nutrient availability of miscellaneous crop by-products used in livestock feed. The larger the herd the more fuelwood is needed to cook the *kundo*. Since fuelwood is seldom purchased, the "price" is based on time required for collection of a unit of fuelwood (a standard load, a *bhari*, was measured to be approximately 20 kilograms of fuelwood). Two alternate price estimates can be made here—one in terms of time required and the other incorporating the average wage rate for agricultural labor. The information on wage rates for women in particular was relatively poor because very few women worked for wages. Consequently, this derived price is also mainly a function of time required for fetching fuelwood. Time required to fetch a load of fuelwood is determined by the distance to the source, which will increase as deforestation progresses.

The relationship of fuelwood use to price (time required to collect a *bhari* of fuelwood) and income factors is illustrated in Figures 5-7. With rising household income, fuelwood consumption generally increases through the first seven deciles, after which there appears to be a declining trend.²⁴ For kerosene, which is used mainly for lighting, there is a fairly steady increase in use with income growth. There is a rapid reduction in fuelwood consumption with increasing time per load. For estimating the magnitude of these changes and its implication for total time spent on fuelwood collection, two sets of equations are specified.²⁵ In the first,

$$FW = f(\text{Log } Y, FW_p, HS, L, MB),^{26} \quad (1)$$

where

FW = quantity of fuelwood consumed
(in kilograms per capita per year),

Y = total household income (rupees
per capita per year),

FW_p = fuelwood price in time per load
(8-hour days),

HS = household size,

L = livestock units,²⁷ and

MB = maize by-products (in kilograms).

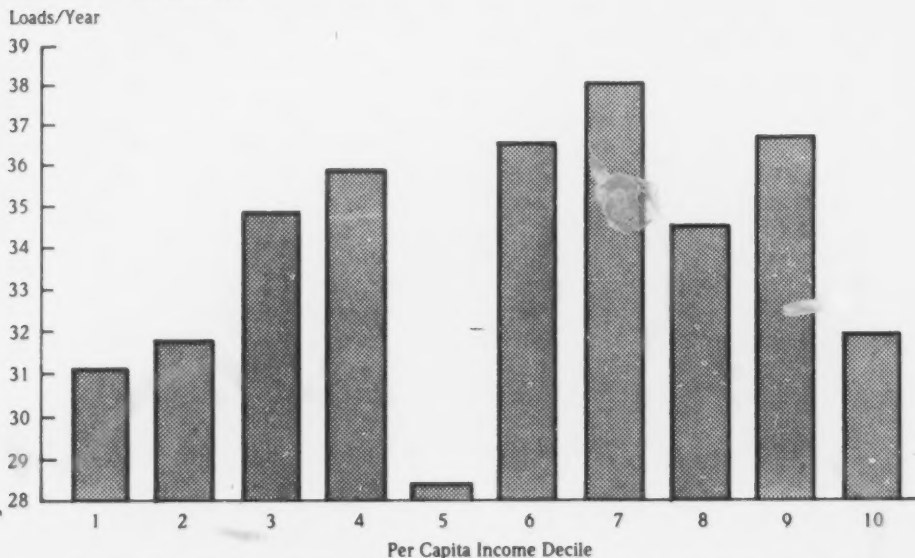
²⁴ The quadratic specification for the income effect on fuelwood use is, however, insignificant. This could be due to the inexplicably reduced use of fuel in the fifth decile.

²⁵ Although there appears to be some substitution of kerosene for fuelwood at higher income levels, deforestation is not found to be a factor in the shift.

²⁶ This equation was specified in both semilog and quadratic forms, but the semilog form was a better fit. The quadratic term was insignificant for both the household and per capita equations.

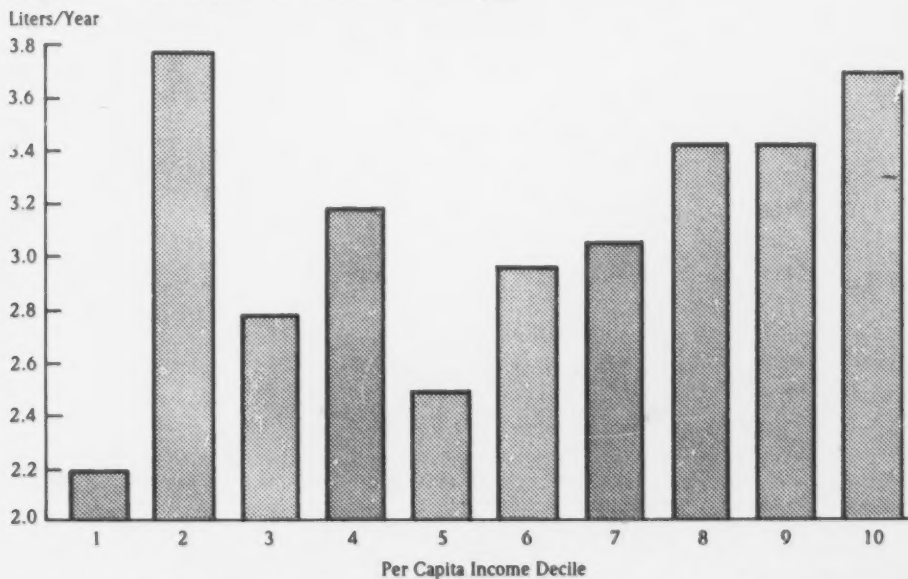
²⁷ Livestock were weighted as follows: buffalo, 1.5; cows and bullocks, 1.0; and sheep and goats, 0.2.

Figure 5—Per capita fuelwood consumption, collected by family and nonfamily members



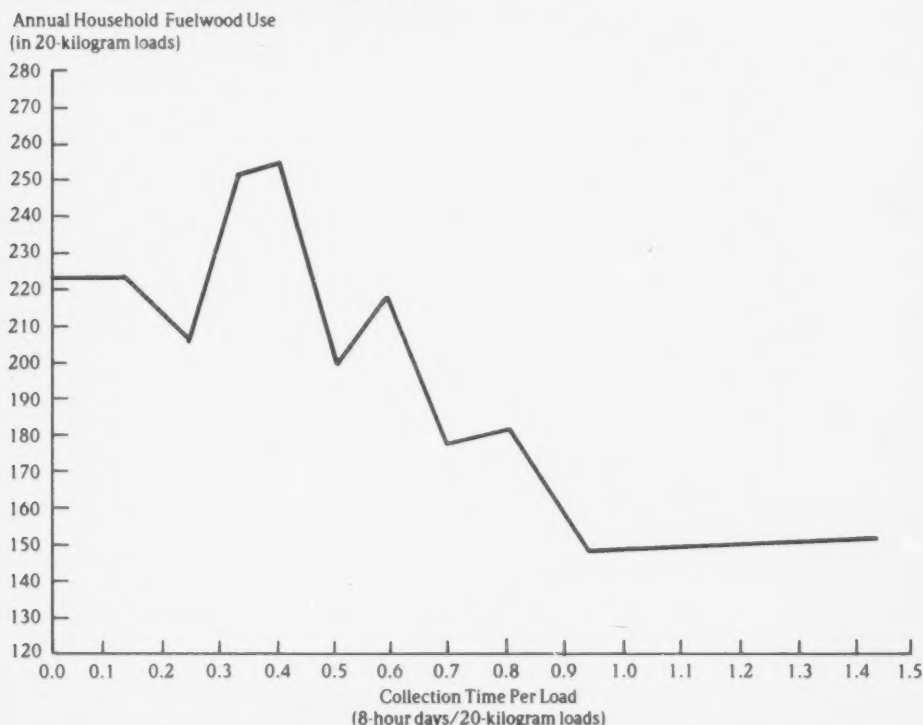
Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Figure 6—Per capita kerosene consumption



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Figure 7—Fuelwood consumption using collection time per load as an indicator of deforestation



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: Each point represents one-tenth of the sample.

Second,

$$TFW = f(\log Y, FW_p, HS, L, MB), \quad (2)$$

where

TFW = time spent on fuelwood collection
(8-hour days per capita per year).

These equations are analogous to estimating both the consumption and expenditure consequences of price and income changes. While the second equation is not usually estimated in standard demand analysis, it is interesting given that both price and expenditure are specified in terms of time spent. Results are shown in Table 7. Calculations of elasticities for fuelwood consumption with respect to the increasing price of wood indicate that a 10 percent rise in price of wood, or the time taken for collection of one unit, will reduce its consumption by only 2-3 percent but will increase the time spent for its collection by 4-6 percent. This is consistent with a relatively inelastic response characteristic of a basic necessity. The income response best captured by a

Table 7—Factors explaining fuel collection and use, 1982/83

Explanatory Factor	Average	Fuelwood Use		Time Spent Collecting Fuelwood	
		Marginal Propensity to Consume	Elasticity	Marginal Propensity to Consume	Elasticity
		(20-kilogram loads/capita/year [$x = 33.7$])		(8-hour workdays/capita/year [$x = 18.3$])	
Intercept	...	43.76**	...	14.25*	...
Log of total annual income (Rs/capita)	Rs 1,954.0	2.76† (1.72)	0.8	0.37 (0.38)	...
Average household size	6.6	-3.67** (-8.37)	...	-1.56** (-5.91)	...
Livestock units	7.0	0.43† (1.67)	...	0.19 (1.19)	...
Maize by-products produced per household (kilograms)	820.9	0	...	0	...
Time per load to collect ^a	0.61	-14.73** (5.44)	-0.3	16.94** (10.35)	0.6
$\bar{R}^2$ (adjusted)	...	0.47	...	0.62	...

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Figures in parentheses are t-values. The size of the sample was 117.

^a Time per load is determined using the following equation: $FWP_1 = (\text{Time per load [hours]}/8) \times (\text{workdays})$.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

†Significant at the 0.10 level.

semilog functional form is small but significant. The income elasticity is found to be between 0.08 and 0.09.

Other results from this estimation indicate that, first, per capita consumption of fuelwood is lower in larger families, as is the time spent per adult in its collection; second, livestock has a small effect on raising fuel demand; and third, availability of maize by-products, often cited as a fuel source in the study area, has no effect on the total fuelwood demand.

The preceding analysis is restricted to fuelwood use. Other forest products, such as leaf fodder and grass for livestock and water from streams, would also recede with deforestation. Because, as mentioned earlier, their location in forests is more localized, the association of distance and deforestation is difficult to document in this cross-sectional study. Whereas the demand for water is likely to be as inelastic as that for fuelwood, the demand for livestock feed is influenced by changes in livestock holdings or feeding practices. If their consumption response is similar to that of fuelwood, that is, relatively inelastic, then the overall implications for demand for household and especially women's time would be correspondingly higher with increasing deforestation.

Implications of Deforestation for Time Allocation

In examining the time allocation patterns of the sample households by degree of deforestation, using simple tabular analysis, time spent on fuel-collection activities is examined separately for lowland and highland sites (Table 8). The average time per

Table 8—Pattern of time allocation and deforestation, 1982/83

Time Spent per Activity	Time Taken to Collect a Load of Fuelwood					
	Lowlands			Highlands		
	Low Deforestation	High Deforestation	Percent of Change	Low Deforestation	High Deforestation	Percent of Change
Time/load of fuelwood (minutes)	106	193	82	163	270	66
Fuel collection time (hours/day)	1.5	3.0	100	2.3	2.9*	26
All adults	1.3	2.6*	100	2.1	2.8*	33
Women	1.1	2.5*	127	1.9	2.6*	37
Children	0.2	0.4	100	0.2	0.1	-50
Per capita fuel collection time (hours/person/day)	0.3	0.4†	33	0.4	0.5	25
All adults	0.5	0.8*	45	0.7	1.0*	43
Women	1.0	1.6*	60	1.2	1.8*	50
Agricultural labor (hours/day)						
Women's field work						
Per capita	2.7	2.7	0	3.3	2.7	-17
Per hectare	2.8	1.5*	-46	2.8	1.8*	-36
Men's field work						
Per capita	1.9	4.1*	116	3.7	2.8	-23
Per hectare	2.2	2.7	23	3.1	1.7*	-42
Wage labor	0.7	0.9	29	0.3	0.5*	67
Cropped area (hectares)	1.4	3.2*	129	2.1	2.5	19

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

*Significant at the 0.05 level.

†Significant at the 0.10 level.

trip for households in each ward is used as a proxy for the degree of deforestation in the area. In addition to the pattern of household time allocation for fuel collection, field work time by men and women is also tabulated by the degree of deforestation (or time per trip for fuelwood).

Table 8 shows that the time per trip for fuelwood increased 82 percent in the lowland wards and 66 percent in the highland wards, or an average of about 75 percent as deforestation increased. According to the earlier regression results, it would be expected that a 75-percent rise in the time per trip for fuel would increase the time spent in collection by 45 percent. The difference in increase in time spent for fuel collection between the low and high deforestation sites, in both the valley and hillside sites, is in line with the expected values from the earlier regression results. Whereas the total fuel collection time per household increased 100 percent for the lowland sites, it rose 26 percent for the highland sites. On a per capita basis, however, the average increase for lowland and highland sites combined was about 45 percent for adults and 50-60 percent for women.

Collection of fuel and other forest products, such as leaf fodder and grass, is largely done by women; women account for 72 percent of the time spent on this work (see Table 6).²⁸ On average, women spend 2.5 hours per day on such activities. This is

²⁸ This figure includes collection time for fuelwood, leaf fodder, and grass.

only slightly less than the time they spend on farm labor—about 2.8 hours per day averaged over a year. If the increase in time required for collection is borne entirely by women, and if they take all of this additional time away from farm labor, it would lead to a reduction in their farm labor input of 1.4 hours daily or a decrease of 50 percent, leading to a total reduction in farm labor of 24 percent if not substituted for by other household members or by hired labor.

To see the effect of deforestation on farm labor input, the following analysis is undertaken. First, simple tabular analysis shows that in the highland sites, where the cropped area between the two deforestation groups is similar, there is a substantial reduction in women's field labor on both a per capita and a per hectare basis. The only exception is their per capita labor input in the lowland sites. The explanation for that probably lies in the 129 percent higher amount of area cultivated, which would demand additional labor input. Despite this increase in area, women's labor per capita was no higher in the high deforestation sites. Surprisingly, men in the highland sites also showed a reduction in time spent in field labor, which was statistically significant for their hours spent per hectare. At the lowland sites with the higher amount of deforestation, there is also a significantly larger amount of area cropped. As seen earlier, household labor for both women and men increases with income (and area farmed). Consequently, the results of the tabular analysis reflect the combined effects of both deforestation and cropped area.

To some extent, there is an increase in wage labor use in the areas with higher deforestation. Even though the percentage of the increase is quite substantial, in absolute terms it does not appear to make up for the decrease in household labor input in these areas. A simple demand function for wage labor, however, does not indicate that the degree of deforestation was a statistically significant factor in influencing its use, after controlling for total cropped area and altitude.

In order to control for the main cropping characteristics in the association between deforestation and household labor input in agriculture, the following household labor input equation is estimated:

$$Lh_i = f(Lw, OffY, Tcrl, Pll, FS, Alt, Df), \quad (3)$$

where

Lh_i = household labor input, females and males (hours/day);

Lw = wage labor input (hours/day);

$OffY$ = off-farm income, the sum of remittances and wage incomes (Rs/year);

$Tcrl$ = total cropped area (hectares);

Pll = proportion of lowland in cropped area;

FS = number of resident adults in household;

Alt = altitude (high altitude wards = 1, others = 0); and

Df = deforestation (wards where time per trip is high = 1, others = 0).

Total household labor input, as well as that of males and females, is expected to be a function of, first, household cropping characteristics such as total cropped area and proportion of lowland, both of which would tend to increase labor input if the income effect on labor input is greater than the substitution for leisure; second, use of wage labor and off-farm income, which may be expected to reduce household labor input; third, number of adults, which would increase total and per hectare labor input; fourth, deforestation, which would reduce household labor input; and fifth, altitude.

Results of the estimation equations are given in Table 9. They confirm the negative impact of deforestation on women's farm labor input. Even though men's farm labor also appears to be slightly reduced, this result is not statistically significant. When other household variables are controlled for, total household labor is reduced more than four hours per day, out of which three hours are accounted for by a decline in women's labor input. Also, both the increase in cropped area and the use of wage labor are accompanied by an increase in household labor use, indicating a strong income effect on household labor input. This is not unexpected given the high subsistence orientation and relatively high incidence of malnutrition among children and adults. The low levels of landlessness and hired labor use could also contribute to these results. An increase in the number of adults in the household has the expected positive effect on household labor input, and at higher altitudes, women's farm labor input is significantly higher.

The effect of deforestation on household labor input when estimated on a per person basis indicates a reduction in women's farm labor of 1.6 hours per woman and in men's farm labor of 0.8 hours per man (Table 10). Thus, while the effect for women is more pronounced, there is also some evidence that men may also cut their farm labor input. This could partly be the result of their involvement in collection activities and the higher grazing time required in the high deforestation sites. However, the limited substitutability between men's and women's activities in crop production at the household level could also play a role, especially since additional use of wage labor is limited.

The tabular analysis in Table 8 indicates a somewhat smaller reduction in labor time per person. There are, however, differences between the low-altitude and high-altitude sites. These differences can be traced to the larger areas cropped, especially in the low-altitude areas of the high deforestation sites. This correlation between deforestation and area cropped in the cross section is likely to be due to a two-way causality between the two.

Results of the regression analysis show that an increase in cropped land tends to be associated with higher household labor inputs, which partly offset the effect of deforestation alone. When Equation 3 is estimated for labor input per hectare, it is found that deforestation reduces household labor input by about 1.9 hours per hectare or by about 40 percent (Table 11). This is after controlling for the negative effect of the increasing cropped area on intensity of labor input.

Net Change in Women's Work Load with Deforestation

Results of the fuelwood equations indicate that a 1 percent increase in total collection time increases time spent collecting fuelwood by 0.6 percent and decreases the amount of fuel consumed by 0.3 percent. The time required to collect one load of fuelwood increased by about 75 percent where deforestation was high. This implies about a 45 percent increase in the time allocated for firewood collection. What is the implication of this result for the total activities surrounding collection of forest products? These

Table 9—Effects of deforestation on input of household farm labor in hours per day

Variable	Mean	Household Labor Input		
		Total	Females	Males
			(hours/day)	
Intercept	...	-2.22 (1.4)	-0.91 (1.2)	-1.29 (1.2)
Wage labor (hours/day)	1.3	1.11* (2.4)	0.74** (3.3)	0.38 (1.2)
Off-farm income (Rs/year)	2,865	-2.88 ^{E-05} (0.2)	4.50 ^{E-05} (0.7)	-7.01 ^{E-05} (0.8)
Total cropped area (hectares)	2.20	3.49** (6.5)	-1.44** (5.6)	2.05** (5.7)
Proportion of lowland in cropped area	0.41	0.76 (0.28)	0.22 (0.2)	-1.06 (0.6)
Number of adults per household	3.4	1.36** (3.3)	0.57** (2.8)	0.78** (2.8)
Altitude (high = 1, low = 0)	0.50	1.47 (1.2)	1.54** (2.6)	-0.07 (0.1)
Time per trip for fuel (high = 1, low = 0)	0.49	-4.37** (3.1)	-3.21** (4.8)	-1.14 (1.2)
R ² (adjusted)	...	0.65	0.63	0.55

Notes: Means for the dependent variables are total household labor, 9.7 hours per day; female labor, 4.6 hours per day; and male labor, 5.1 hours per day. The figures in parentheses are t-ratios.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

products are mainly fodder and grass for animals, but over time the availability of water would also be influenced by deforestation because the forest streams from which most household water is obtained would eventually dry up without their forest cover.

Women's time spent collecting fuelwood, fodder, and grass for the sample households was found to be 2.5 hours per person per day averaged over the year. If the response function for other forest products is assumed to be similar to that for fuelwood, one would expect that women's time spent collecting forest products would also increase by 45 percent (assuming the increased requirement is evenly distributed among all household members). That would lead to a daily increase in women's collection time for these products of 1.13 hours per day. It was estimated earlier that women's field labor decreased by 1.6 hours per day due to the effect of deforestation. However, since cropped area in the high deforestation sites tends to be higher, and this contributes to a higher demand for household labor, the actual fieldwork of women decreases by about an hour. This is reflected in the cross-sectional comparison in Table 8, which indicates a relatively small reduction in fieldwork per person with deforestation. The implications of deforestation, therefore, are two-fold: first, the work load of household members is raised, and second, labor input per hectare is reduced, with possible adverse yield effects. This reduction occurs even after controlling for cropped area, as shown in the previous section.

Table 10—Effects of deforestation on input of household farm labor in hours per person per day

per person per day			
Variable	Mean	Household Labor Input	
		Females	Males
(hours/person/day)			
Intercept	...	2.05** (4.1)	1.79** (3.8)
Wage labor (hours/day)	1.30	0.10 (0.7)	0.10 (0.8)
Off-farm income (Rs/year)	2,918	3.43 ^{E - 05} (0.8)	1.61 ^{E - 05} (0.4)
Total cropped area (hectares)	2.20	0.87** (5.2)	1.07** (6.9)
Proportion of lowland in cropped area	0.41	1.12 (1.3)	0.89 (1.1)
Number of adults per household	3.4	-0.4** (3.0)	-0.47** (3.8)
Altitude (high = 1, low = 0)	0.50	0.49 (1.3)	0.37 (1.0)
Time per trip for fuel (high = 1, low = 0)	0.49	-1.57** (3.6)	-0.79* (2.0)
R ² (adjusted)	...	0.31	0.45

Notes: The figures in parentheses are t-ratios. Means for the dependent variables are female labor, 2.8 hours per person per day and male labor, 2.9 hours per person per day.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 11—Effects of deforestation on input of household farm labor per day in hours per hectare

in hours per hectare		
Variable	Household Labor Input	
	Mean	Coefficient
(hours/hectare/day)		
Intercept	...	3.27** (5.26)
Wage labor (hours/hectare/day)	0.57	1.08** (3.0)
Off-farm income (Rs/year)	2,865	6.19 ^{E-06} (0.1)
Total cropped area (hectares)	2.20	-0.18 (1.2)
Proportion of lowland in cropped area	0.41	0.63 (0.63)
Number of adults per household	3.4	0.41** (2.7)
Altitude (high = 1, low = 0)	0.50	0.57 (1.2)
Time per trip for fuel (high = 1, low = 0)	0.49	-1.86** (3.6)
R ² (adjusted)	...	0.18

Notes: The mean for the dependent variable is 4.5 hours per hectare per day. The numbers in parentheses are t-ratios.

**Significant at the 0.01 level.

AGRICULTURAL PRODUCTION CHARACTERISTICS

Implications of Deforestation for Production

What are the consequences for production of increasing the demand on women's time of collection activities? Not only does their total work load increase, but time spent on directly productive activities is reduced. This could have adverse consequences on income, primarily from agricultural production.

The previous section confirmed that household labor input, and especially the women's labor component of time spent in farming on a household and per-person basis, declines with a higher degree of deforestation, as reflected in the time per trip for fuel collection. At the same time, men's labor input also decreases. This could be due at least in part to lack of perfect substitutability between women's and men's labor. Detailed studies of time allocation from Nepal suggest that there are some activities for which sexual division of labor is more rigid than for others. Agricultural activities described as being almost exclusively carried out by women are seed selection, weeding, and application of organic manures.²⁹ If the extent to which men's labor can be substituted for women's is limited, then reduction in women's labor could also reduce men's labor if men must wait for women to complete their tasks. Other contributing factors may be more time spent by men on livestock grazing and increased seasonal migration by men.

The extent of this decline in agricultural labor is greater when controlling for cropped area in the regression analysis than in the cross-sectional comparisons. This is partly explained by the larger amount of area cropped at higher deforestation sites, and it is especially pronounced for the lowland sites. These larger land areas are consistent with the central thesis that excessive land clearing contributes to deforestation. An increase in cropped land is found to have a strong income effect on labor input. An increase of 1 hectare in cropped area increased household labor by 3.5 hours per day, women's labor by 1.4 hours per day, and men's labor by 2.1 hours per day (Table 9).

In sum, high deforestation sites have greater demand for labor both for collection activities and for agricultural labor. This is reflected in a significantly larger household size and a lower number of permanent and seasonal migrants from these sites. The possible long-term demographic implication of this kind of response to deforestation, while not possible to explore in this report, should be examined further. Labor input per hectare is significantly lower in the high deforestation sites, and both female and male labor are reduced when cropped area and proportion of lowland cropped are controlled for.

What are the implications for agricultural production? The production response to these reductions in labor input is indicated by the factor shares and the marginal

²⁹ Bina Pradhan, *The Newer Women of Bulu*, vol. 2, part 6 of *The Status of Women in Nepal* (Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, 1981); and Sidney Schuler, *The Women of Baragaon*, vol. 2, part 5 of *The Status of Women in Nepal* (Kathmandu: Centre for Economic Development and Administration, Tribhuvan University, 1981).

product of labor. Women's labor is primarily influenced by deforestation, but the degree of substitutability between men's and women's labor influences the reduction in men's labor. These issues are examined in the next section.

Significance of Labor to Agricultural Production

The main crops grown in the study area are wheat, early paddy, and paddy for lowland plots, and maize and ragi (finger millet) for upland plots. A small proportion of maize is planted on lowland plots. Mustard and blackgram are also grown, and both provide essential dietary ingredients. Production data recorded for each crop were area; labor input in days, by household and by wage labor of men, women, and children; days of animal labor used in crop production; purchased fertilizer use; and output. Aggregate observations for each crop are given in Table 12. Levels of labor input and yields for cereals are within the range expected for hill regions.³⁰ The yields for both mustard and blackgram are on average substantially lower than expected, and the variation in their yields is also very high. This would indicate either extreme riskiness in production of these crops or some underlying problem in reporting. The ratio of output to total labor days, indicating the average product of labor, is highest for early paddy at 7.7 kilograms and lowest for blackgram at 1.2 kilograms.

In order to estimate the marginal product of land, human labor, and animal labor in the production of each crop, translog or specific production functions are used. In the first equation, an interaction term for aggregate labor input and area is included to test whether the effects of each are influenced by the level of the other. This is used later to determine the factor shares and marginal products for small and large farms. The equation is

$$\text{LogP} = f(\text{LogA}, \text{LogL}_t, \text{LogL}_v, \text{LogALogL}_t), \quad (4)$$

where

P = crop output (in kilograms),

A = crop area,

L_t = total human labor input (in days
of family and hired labor), and

L_v = animal days used.

Next, the marginal product of men's and women's labor input in crop production is tested. This is considered important for two reasons. First, there is reason to expect, given the nature of sexual division of labor in Nepal, that there may not be perfect substitutability between men's and women's labor. Second, it has been documented that women carry nearly the entire work load for fuel, fodder, grass, and water collection as well as food processing and cooking. So if "women's tasks" in crop production are not easily assumable by men, then it would indicate that, in order to increase agricultural productivity, an improvement in productivity of women's tasks in nonagricultural activities may also be essential to increase agricultural production.

To test the homogeneity between men's labor and women's labor, the production function is tested to see if it is separable into these subaggregates. Separability implies

³⁰ Nepal, Agricultural Projects Services Centre, *Nepal: Foodgrain Marketing and Price Policy Study*.

Table 12—Basic crop production data, 1982/83

Crop	Number of Cultivating Households (N = 118)	Area (hectares)	Yields (kilogram/ hectare)	Labor Use						Total Labor	Ox-days (days/ hectare)	Fertilizer Used (kilogram/ hectare)	Average Production/ Labor Day (kilogram/ labor day)
				Household Labor		Wage Labor							
				Men	Women	Men	Women	Men	Women				
Wheat	46	0.40	1,008	78	82	12	5	177	9	112.4	5.7		
Maize	113	0.66	1,183	77	82	17	10	186	28	...	6.4		
Early paddy	54	0.40	1,751	108	103	8	9	228	23	...	7.7		
Paddy	97	0.67	1,863	165	105	37	11	318	67	...	5.9		
Ragi	92	0.50	955	111	162	7	8	288	27	...	3.3		
Mustard	38	0.18	263	46	59	15	10	130	74	...	2.0		
Blackgram	53	0.40	210	54	71	23	26	174	53	...	1.2		

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: The ellipses indicate a nil or negligible amount.

that marginal rates of substitution between pairs of factors in the separated group are independent of the levels of factors outside that group.³¹ In this case, the subaggregates are men's (L_m) and women's (L_f) labor, and area is used as the factor outside the group. If the true production function is weakly separable into L_m and L_f , and the separable form of a translog function is interpreted as an exact production function used as a Cobb-Douglas function of translog subaggregates, then

$$\ln P = f[\ln L_t (\ln L_m, \ln L_f), \ln A \dots], \quad (5)$$

where L_t is the aggregate labor input. For $f(\ln L_t, \ln A)$ to be linear in $\ln L_t$ and $\ln A$ only, then it has to be shown that $\ln L_t$ is quadratic in $\ln L_m$ and $\ln L_f$. For the argument of separability, that is, the homogeneity of men's and women's labor, to hold, the constraints to apply are

$$\ln L_m \cdot \ln A = \ln L_f \cdot \ln A = 0. \quad (6)$$

It is assumed that production is a linear function of both land and labor, with a declining marginal product for both. The coefficients for the squared terms are therefore set equal to 0. The equation estimated is

$$\ln P = f(\ln A, \ln L_m, \ln L_f, \ln L_m \cdot \ln A, \ln L_f \cdot \ln A, \ln L_t), \quad (7)$$

where L_m is men's labor input for the crop (in days of family and hired labor), and L_f is women's labor input for the crop.

Results from these three equations are used to calculate the marginal products and factor shares for each input at its mean value in use. These are shown in Tables 13, 14, and 15. The main observations from these tables are as follows:

1. The production response of labor is consistently significant, and its factor share is higher than that for land for all crops except early paddy. Also, the marginal product value for most crops is equal to or greater than the prevailing wage rates, indicating that despite the small size of average holdings, hill agriculture does not represent a labor surplus situation, and labor is a significant constraint in the production of most crops grown.
2. Wheat and paddy have the highest marginal products with increasing labor input. These are predominantly lowland crops. The upland crops, maize and ragi, have a lower marginal productivity of labor. A comparison with local wage rates—Rs 8.00 per day for men and Rs 5.00 for women—suggests that wages are comparable to the marginal product of labor for maize and ragi, but are lower than those for wheat and paddy if rice is priced at Rs 5.00 per kilogram and wheat, ragi, and maize at Rs 3.00 per kilogram.
3. The marginal product of men's and women's labor is found to be independently significant for all crops except early paddy, often with different marginal products. The separability test indicates that except for the dry-season crops, wheat and mustard, men's and women's labor are weakly separable, that is, they have different marginal rates of substitution with land. This suggests that, at least for some crops, there is little justification for aggregating men's and women's labor.

³¹ Michael Denny and Melvyn Fuss, "The Use of Approximation Analysis to Test for Separability and the Existence of Consistent Aggregates," *American Economic Review* 67 (June 1977): 404-418.

Table 13—Production functions by crop, 1982/83

Table 13—Production functions by crop, 1962/63

Crop	Intercept	LArea	L Labor		LArea × L Labor		L Animal Labor	N	R ² (Adjusted)		
			Total	Men's	Women's	Total				Men's	Women's
Wheat Equation (4)	3.834	0.525 (1.44)	0.521* (2.82)	...	...	-0.081 (-0.86)	...	46	0.59		
Equation (7)	4.632	0.78* (2.99)	...	0.37* (2.13)	-0.014 (-0.14)	...	0.116* (2.03)	-0.326* (-3.72)	-0.002 (-0.04)	46	0.64
Early paddy Equation (4)	5.284	0.800 (1.49)	0.515 (1.60)	...	...	-0.018 (-0.13)	...	54	0.56		
Equation (7)	5.369	0.708 (1.42)	...	0.454 (1.43)	-0.053 (-0.35)	...	0.020 (0.11)	-0.027 (-0.18)	0.026 (0.26)	54	0.56
Maize Equation (4)	3.699	-0.026 (-0.08)	0.393* (2.53)	...	...	0.047 (0.63)	...	112	0.62		
Equation (7)	4.453	0.153 (0.73)	...	0.031 (0.20)	0.193* (2.25)	...	0.049 (0.51)	-0.024 (-0.25)	0.421* (3.33)	112	0.65
Ragi Equation (4)	2.802	0.796* (2.71)	0.617* (5.62)	...	...	-0.171* (-2.71)	...	92	0.67		
Equation (7)	3.536	0.723* (2.57)	...	0.409* (2.00)	0.151 (0.77)	...	0.000 (0.0)	-0.167 (-1.10)	0.057† (1.79)	92	0.66
Paddy Equation (4)	3.640	0.340 (1.40)	0.638* (4.63)	...	...	0.1010 (0.19)	...	97	0.79		
Equation (7)	4.039	0.353† (1.68)	...	0.455* (3.15)	0.175 (1.09)	...	-0.119 (-1.01)	0.147 (1.11)	0.055 (0.57)	97	0.79
Blackgram Equation (4)	-1.733	-0.49 (-1.27)	1.02* (2.15)	...	...	-0.01 (-0.15)	...	52	0.47		
Equation (7)	-0.855	-0.46 (-1.28)	...	0.10 (0.10)	0.83 (0.93)	...	-0.25 (-0.49)	0.23 (0.46)	0.33 (0.77)	52	0.46
Mustard Equation (4)	1.364	0.23 (0.73)	0.43 (1.21)	...	...	-0.002 (-0.02)	...	37	0.62		
Equation (7)	2.210	0.32 (1.49)	...	1.35* (3.62)	-1.14* (-2.55)	...	0.58* (3.37)	-0.57* (-3.41)	0.53* (2.27)	36	0.74

Notes: Equation (4) is $\text{Log}P = f(\text{Log}A, \text{Log}L_v, \text{Log}AL\text{og}L_v)$, where P is crop output, A is crop area, L_v is total human labor input, and L_v is animal days used. Equation (7) is $\text{Ln}P = f(\text{Ln}A, \text{Ln}L_m, \text{Ln}L_w, \text{Ln}L_v, \text{Ln}L_v \cdot \text{Ln}A, \text{Ln}L_v \cdot \text{Ln}L_m, \text{Ln}L_v \cdot \text{Ln}L_w)$, where L_m is men's labor input for the crop and L_w is women's labor input for the crop.

*Significant at the 0.05 level.

†Significant at the 0.10 level.

Table 14—Marginal products in kilograms of primary factors for total sample, 1982/83

Crop	Area (hectares)	Total Days of Labor			Days of Animal Labor
		Men's	Women's	Both	
Wheat					
Equation (4)	242.2 ^a	...	...	4.5	-2.6 ^a
Equation (7)	242.2	2.5	7.4	...	0.0 ^a
Early paddy					
Equation (4)	1,259.1 ^a	...	...	3.7 ^a	2.4 ^a
Equation (7)	1,311.6 ^a	7.3 ^a	1.7 ^a	...	2.4 ^a
Paddy					
Equation (4)	719.5 ^a	...	...	3.8	1.5 ^a
Equation (7)	738.0	20.6	0.9 ^a	...	1.8 ^a
Blackgram					
Equation (4)	-634.9	...	...	0.9	1.0
Equation (7)	-57.3	0.9	0.8	...	1.2
Maize					
Equation (4)	220.7 ^a	...	...	2.1	12.4
Equation (7)	302.0 ^a	-0.7 ^a	2.4	...	15.7
Ragi					
Equation (4)	52.8	...	...	2.5	2.0
Equation (7)	79.2	3.0	1.9 ^a	...	2.0
Mustard					
Equation (4)	30.8	...	...	0.8	2.1
Equation (7)	44.2	0.2	0.5	...	2.1

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Equation (4) is $\log P = f(\log A, \log L, \log L_v, \log A \log L, \dots)$, where P is crop output, A is crop area, L is total human labor input, and L_v is animal days used. Equation (7) is $\ln P = f(\ln A, \ln L_m, \ln L_w, \ln L_m \cdot \ln A, \ln L_w \cdot \ln A, \ln L_m \cdot \ln L_w, \dots)$, where L_m is men's labor input for the crop and L_w is women's labor input for the crop. The ellipses indicate a nil or negligible amount.

^a These figures are marginal; they are not based on any significant coefficients.

4. The marginal product of women's labor is found to be substantially higher than that of men's labor for wheat, maize, and mustard. It should be noted that these are all dry-season crops—a time when there could also be increased competition from fuel and other collection activities, all of which are performed mainly by women.
5. For the paddy crop, men's labor input is the main constraint. For ragi, the other main wet-season crop, men's and women's labor is equally important. For wet-season crops, it is possible that women's labor may be more readily available because the burden of collection activities is reduced.
6. Among the cereal crops, animal labor is a significant constraint only in maize production. Incremental use of animal labor is also indicated as beneficial for production of both mustard and blackgram. This finding, however, cannot be seen as conclusive and needs to be investigated further.

High factor shares for labor and the significantly positive marginal product for labor found in the above analysis point to labor input as a constraint in agricultural production. This is despite the low levels of improved technological inputs used and the widespread perception of hill agriculture in Nepal as being labor surplus. Factor shares and marginal

Table 15—Factor shares of land, labor, and livestock in crop production, total sample, 1982/83

Crop	Area (hectares)	Total Days of Labor			Days of Animal Labor
		Men's	Women's	Both	
Wheat					
Equation (4)	0.24 ^a	...	...	0.63	-0.03 ^a
Equation (7)	0.24	0.20	0.45	...	0.00 ^a
Early paddy					
Equation (4)	0.72 ^a	...	...	0.41 ^a	0.03 ^a
Equation (7)	0.75	0.42 ^a	-0.09	...	0.03 ^a
Paddy					
Equation (4)	0.39 ^a	...	...	0.63	0.05 ^a
Equation (7)	0.40	0.55	0.05 ^a	...	0.06 ^a
Blackgram					
Equation (4)	-0.52	...	...	1.04	0.28
Equation (7)	-0.50	0.45	0.48	...	0.33
Maize					
Equation (4)	0.19 ^a	...	...	0.36	0.33
Equation (7)	0.26 ^a	-0.06 ^a	0.20	...	0.42
Ragi					
Equation (4)	0.06	...	...	0.80	0.06
Equation (7)	0.09	0.41	0.34 ^a	...	0.06
Mustard					
Equation (4)	0.23	...	...	0.43	0.51
Equation (7)	0.33	0.05	0.14	...	0.53

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Equation (4) is $\log P = f(\log A, \log L, \log L_v, \log A \log L)$, where P is crop output, A is crop area, L is total human labor input, and L_v is animal days used. Equation (7) is $\ln P = f(\ln A, \ln L_m, \ln L_w, \ln L_m \cdot \ln A, \ln L_w \cdot \ln A, \ln L_m)$, where L_m is men's labor input for the crop and L_w is women's labor input for the crop.

^a These factor shares are not based on any significant coefficients.

products were also calculated for small and large farms and were found to be similar in the present specification (Table 16). Sample sizes were too small for separate estimations.

The results of this analysis in conjunction with the earlier results on the reallocation of household labor with deforestation provide evidence of a labor constraint and of a declining aggregate productivity in agriculture resulting from reductions in labor input. This is further confirmed in this study by the significantly lower yield for the dry-season crops in the high deforestation sites (Table 17). The results also suggest that, first, adverse effects of deforestation on agricultural productivity will be relatively more pronounced on the smaller farms; second, introduction of improved agricultural technologies that require higher labor input may be problematic on smaller farms unless improvements in labor productivity are accessible for other essential tasks being performed by household members; and third, if improvements in agricultural labor productivity are possible, there is less likely to be a push for expanding area under cultivation than there would be in a labor-surplus situation.

Table 16—Characteristics of crop production on large and small farms, by cropped area, 1982/83

Table 10—Characteristics of Crop Production on 22,800 Farms													
Crop	Number of Households Cultivating	Area (hectares)	Yield (kilograms/hectare)	Labor Use				Total Labor (days/hectare)	Fertilizer (kilograms/hectare)	Marginal Factor Share		Marginal Product	
				Household Labor		Wage Labor				Land	Labor	Land	Labor
				Men	Women	Men	Women						
				(days/hectare)									
(kg/hectare day)													
Smaller farms													
Wheat	25	0.18	1,209	94	110	11	5	226	4	0.26	0.69	244	3.26
Maize	56	0.39	1,169	72	91	21	9	193	25	0.16	0.34	138	1.86
Early paddy	16	0.24	1,679	86	101	6	6	199	20	0.74	0.54	997	4.19
Ragi	52	0.28	856	115	169	9	11	304	19	0.12	0.87	74	2.28
Paddy	41	0.28	2,024	170	109	38	12	328	62	0.38	0.62	637	3.48
Larger farms													
Wheat	28	0.52	831	65	67	18	6	156	12	0.22	0.61	145	3.14
Maize	57	0.92	1,198	92	83	13	13	201	32	0.20	0.38	174	2.02
Early paddy	38	0.46	1,782	117	104	9	10	239	24	0.73	0.54	857	3.55
Ragi	52	0.66	1,071	124	165	5	4	299	35	0.01	0.77	67	2.30
Paddy	56	0.96	1,745	161	103	37	11	311	70	0.39	0.64	602	3.66

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Total cropped area for smaller farms is less than 1.10 hectares. The ellipses indicate a nil or negligible amount.

Table 17—Crop yields by degree of deforestation, for lowland and highland sites combined, 1982/83

Crop	Low Deforestation		High Deforestation	
	(kilograms/hectare)		(kilograms/hectare)	
Paddy	1,802		1,009	
Ragi	1,009		907	
Wheat	1,255		754*	
Maize	1,365		998†	

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

*Significant at the 0.05 level.

†Significant at the 0.10 level.

HOUSEHOLD FOOD CONSUMPTION AND NUTRITION

Relationship Between Income and Food Consumption

In addition to a general description of patterns of consumption and associated characteristics of income and expenditure in the study area, two aspects of food consumption are examined. First, levels of calorie intake³² are analyzed as a function of income, agricultural production, time allocation patterns for women, and quantity of fuelwood used. Then cereal composition of the diet and the possible implications of deforestation on it are analyzed, using a two-step approach. First, the effect of quantity of fuelwood used on cooking time is examined. (There was no variation in the type of stove used in the sample, and cooking time includes all time spent in food preparation.) Second, cooking time is incorporated into an equation to explain the ratio of rice to total calories in the diet.

Rice and maize are the chief dietary staples, with rice consumption expenditure rising rapidly with income (Figure 8).³³ Ragi has a smaller though relatively constant place in the diet. Wheat is consumed in negligible amounts and is largely produced for sale or for wage payments. Expenditures on other foods also increase with income, but not as rapidly as those for rice.

Home-produced items contribute greatly to the household's food basket. Surprisingly, the reported value of purchased foods does not appear to increase much as per capita income rises, but home-produced consumption does. Milk, milk products, and eggs constitute the major part of noncereal food expenditures in home-produced consumption. Total cereal consumption and home-produced cereal consumption are virtually identical.

Allocation of total income to food shows the expected pattern of gradually declining proportions, commonly referred to as Engel's Law (Figure 9). An inflection point occurs at the second income decile, which is a phenomenon that has been observed in other low-income countries.³⁴ This is shown by a rising proportion of income spent on food at very low income levels, before it starts to decline as expected. This occurs only in a seriously deprived population, in which practically *all* income increments are spent on food. It is hypothesized that there are essential nonfood fixed costs that must be incurred even at the lowest income levels, and these prevent a higher proportion of income being spent on food. The proportion of income spent on food rises from about 72 percent in the first income decile to more than 90 percent in the second income decile, before declining to about 40 percent for the highest income decile.

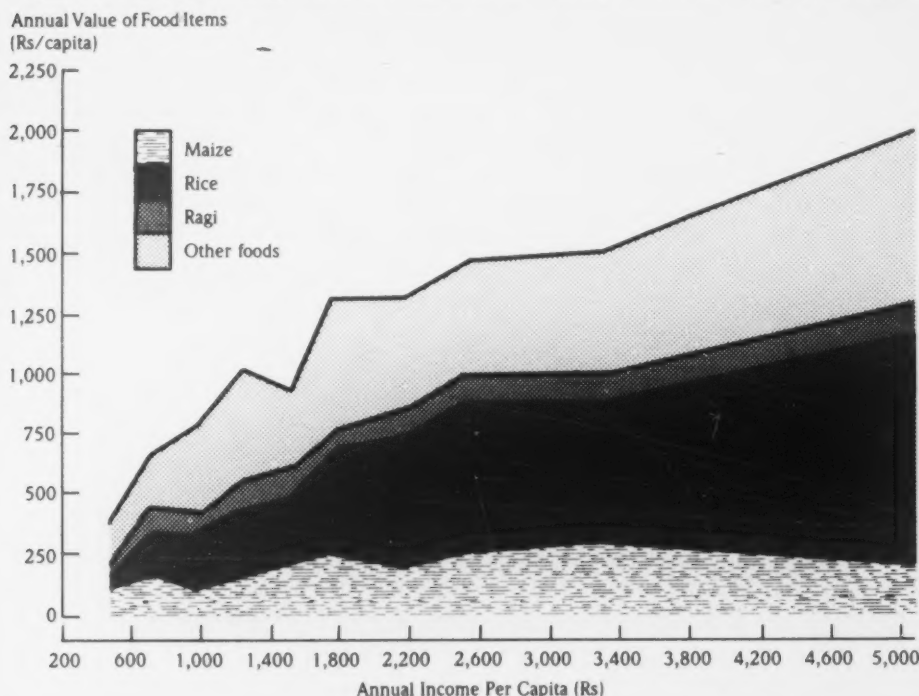
Cash expenditures for food are a much larger share of income at lower income levels, and the share is reduced as incomes rise. However, nonmarket value of consump-

³² All calories referred to in this report are kilocalories.

³³ Rice consumption expenditure refers to the total value of food in the diet, purchased and home-produced.

³⁴ Neville Edirisinghe and R. M. K. Ratnayake, "A Preliminary Analysis of the Determinants of Nutritional Welfare in Sri Lanka," International Food Policy Research Institute, Washington, D.C., January 1984 (mimeographed).

Figure 8—Value of major food items in the diet by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

tion in relation to total income roughly follows the same pattern as did total food expenditures.

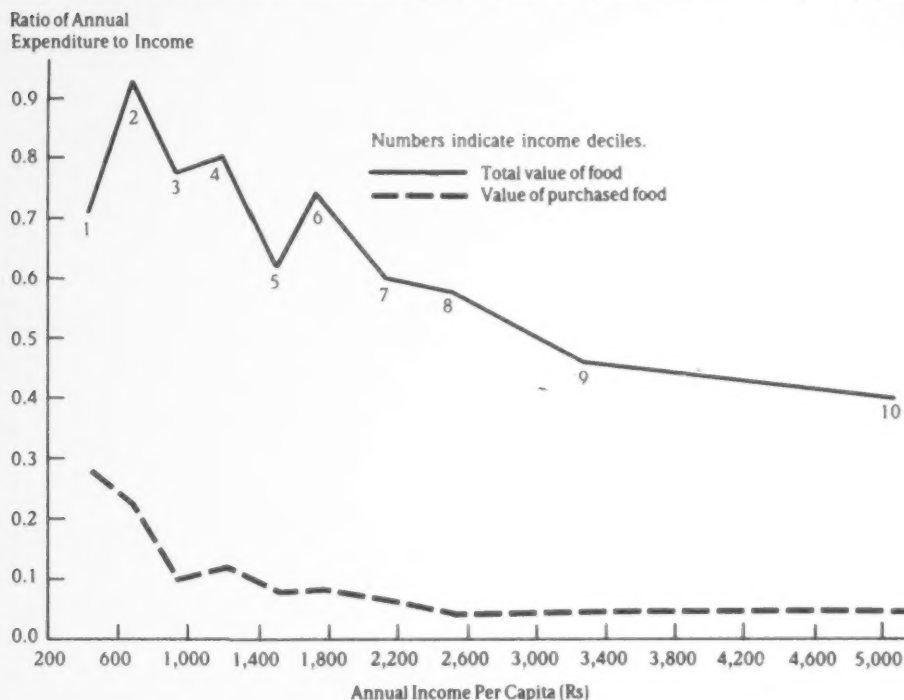
Nonfood expenditures show an interesting pattern in which wage payments clearly become the major increasing expenditure item in this category (Figure 10). This reflects the relatively small amount of other nonfood expenditures incurred, given the limited use of wage labor on aggregate. This observation again emphasizes the labor constraint faced by these households, where an increase in household labor in production is paralleled by an increase in hired labor use.

Consumption reported for individual food items is converted to dietary calories.³⁵ The annual average daily per capita consumption is estimated at 2,137 calories. The distribution by income of caloric consumption is shown in Figure 11.

Finally, the contribution of the main income sources, farm production and remittances, is examined (Figure 12). Though the absolute values of both remittances and farm production rise with income, the ratio of farm production to total income is

³⁵ The estimate of food consumption is based on amounts reportedly kept for home consumption for all field crops, livestock, horticultural produce, food purchases, and foods received as wage payments or gifts. A major disadvantage of this method is that seasonal fluctuations in food consumption cannot be identified.

Figure 9—Proportion of income spent on food by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

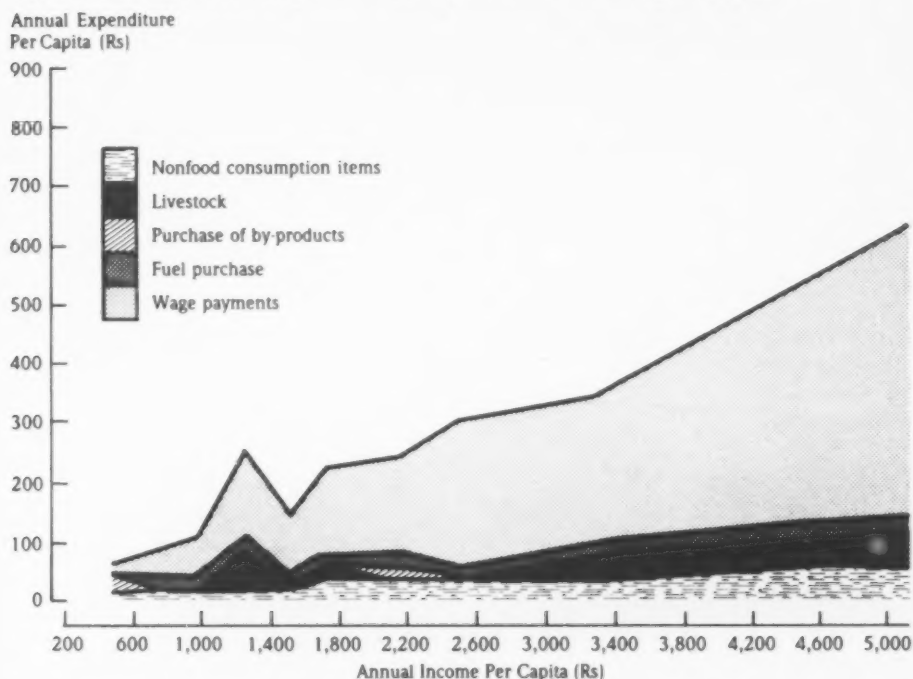
calculated to be about 60 percent for different income levels, and the proportion of remittances varies from about 20 percent of income at the lower income levels to about 10 percent for the middle income group and 16 percent for the highest income group, with no perceptible trend.

Links Between Deforestation, Diet Composition, and Intake

The effects of deforestation on collection time for fuelwood and, by inference, other essential forest products, and the possible effects on agricultural production via a substitution of production time for collection time have already been examined. Here, these effects of deforestation are extended to see if they also affect household food consumption and its composition. Figure 13 shows the pathways by which such effects might occur.

There are several simultaneously occurring mechanisms by which deforestation can be expected to have a direct effect on dietary intake and composition (the indicator of dietary composition used here is the ratio of rice calories to total cereal calories in the diet).

Figure 10—Nonfood expenditures by annual income per capita

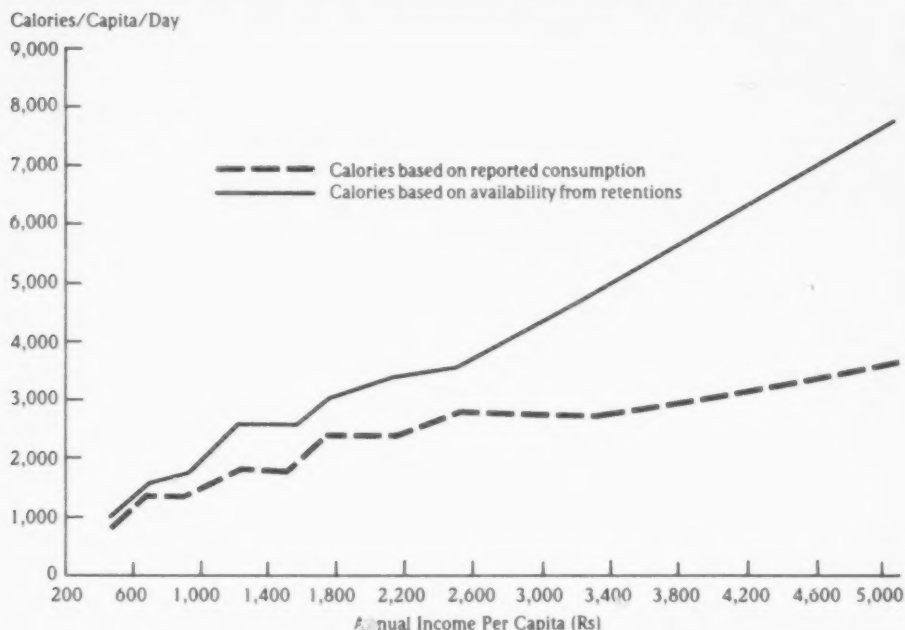


Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

As shown earlier, households use less fuelwood as their time costs rise. The higher collection time may reduce the time available to spend on food preparation and cooking, which in turn may influence both the amount of food consumed and diet composition.³⁶ While higher fuelwood consumption is likely to be associated with higher cooking time, higher collection times may reduce cooking time. The net effect of deforestation would then be to reduce cooking time, because deforestation both reduces fuelwood use and increases time spent in collection activities. To the extent that diets are influenced by the time spent in the kitchen, both qualitative and quantitative aspects of the diet would be relevant in the analysis. If fuelwood shortage affects the composition of the diet, it would be mediated by differences in cooking time for different products or commodities, given no change in the cooking technologies available. Also, if additional time for collection activities with deforestation reduces time available for cooking, the amount of food being consumed may also be reduced.

³⁶ This has been shown for Mexico in Margaret Evans, "Change in Domestic Fuel Consumption in Central Mexico and Its Relation to Employment and Nutrition," working paper prepared for World Employment Research Programme, International Labour Organisation, Geneva, 1986; and Elizabeth Cecelski, "The Rural Energy Crisis, Women's Work, and Family Welfare: Perspectives and Approaches to Action," working paper prepared for World Employment Research Programme, International Labour Organisation, Geneva, 1984.

Figure 11—Estimated calories available by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

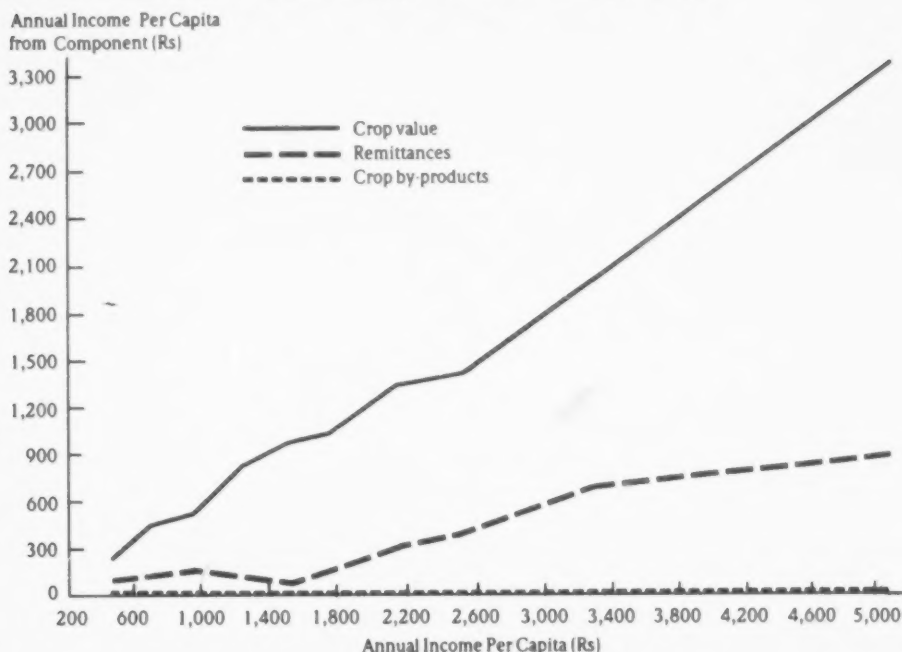
Also, with deforestation, the increased time spent in collecting fuelwood and other forest products, such as fodder and grass, may reduce the time spent on agricultural production, thereby reducing income from agriculture. This would have a direct adverse effect on food consumption.

Cereal Composition in the Diet

Although maize and rice are the two main sources of calories in this region, the households in the study have an overwhelming preference for rice. More than any other food, rice consumption value increases rapidly with income. Rice preparation, however, requires longer cooking time than other cereals. If advancing deforestation means that more time must be allocated to collecting fuelwood, it is hypothesized that cooking time will decrease and, as a result, the amount of rice consumed will be reduced relative to other cereals.

The multivariate analysis consists of two models: a cooking time function that includes independent variables relating to deforestation—amount of fuelwood used and total time spent in its collection, plus household characteristics—and a diet composition function that includes the independent variable, total cooking time. The functional form of the first model is

Figure 12—Sources of income by annual income per capita



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

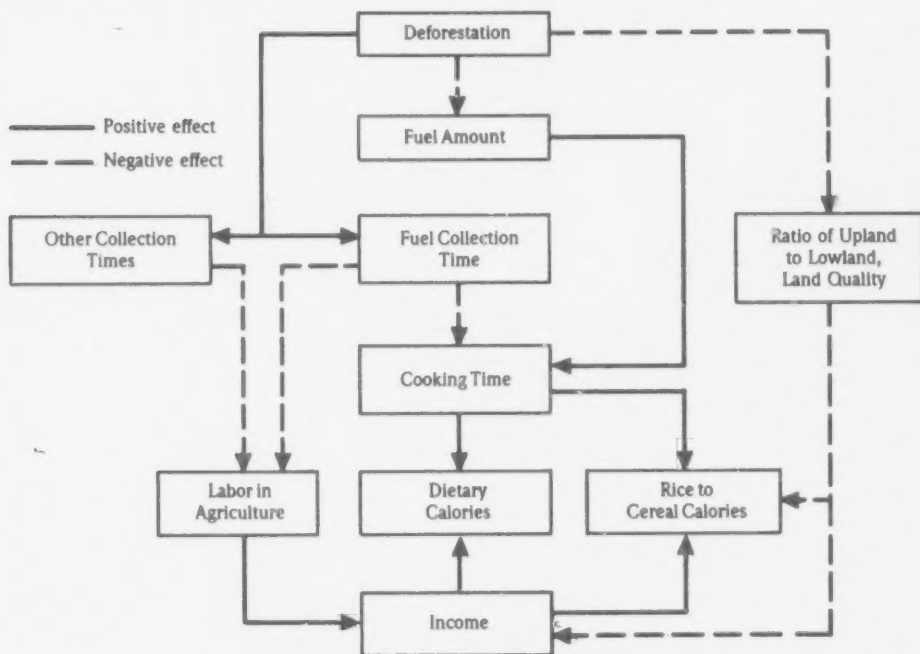
$$C = f(L, T, H, A, AR, DP, WR), \quad (8)$$

where

- C = total cooking and food preparation time per day,
- L = total 20-kilogram loads of fuelwood consumed per year,
- T = total number of eight-hour days spent on fuelwood collection per capita per year,
- H = household size,
- A = livestock units,
- AR = farm size dummy (farm in larger half of farms = 1),
- DP = ratio of children to adults, and
- WR = ratio of women's farm labor time to total farm labor time.

The results in Table 18 indicate that cooking time is positively associated with fuelwood consumption and negatively associated with fuelwood collection time per

Figure 13—Links between deforestation and dietary intake



Source: Based on data collected by Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and the International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

capita. The coefficients of both these independent variables are significant. The results indicate that the additional time necessary for the collection of fuelwood has a negative effect on time for cooking, after controlling for the other variables in the equation. It is also likely that cooking time may be negatively affected by time spent on other activities, such as fuel, fodder, and water collection, that increase with deforestation and place additional burdens on women's time.

Assuming that increasing levels of deforestation decrease time allocated to cooking, a diet composition function is estimated to determine the effect of cooking time on composition of cereal consumption. The functional form of this model is

$$RRICE = f(C, DP, Y, RAR, WR, H), \quad (9)$$

where

RRICE = ratio of calories from rice to calories from other cereals,

Y = total income per capita, and

RAR = ratio of lowland area to total area.

Table 18—Effects of fuelwood use on cooking time

Variable	Cooking Time (Model 1)	Cooking Time (Model 2)
	(minutes/day)	
Intercept	211.11	222.85
Total loads of fuelwood per year (20-kilogram loads)	0.13* (2.10)	0.13* (2.12)
Time spent on fuelwood collection	-0.09 (-1.18)	...
Time spent per capita on fuelwood collection	...	-0.69† (-1.71)
Household size	3.68* (2.15)	2.35 (1.24)
Livestock units	1.82† (1.73)	1.72† (1.68)
Dummy for farm size	-4.53 (-0.50)	-5.04 (-0.56)
Age dependency (children/adults)	-4.52 (-0.43)	-5.04 (-0.49)
Ratio of women's farm labor to total farm labor	-27.81 (-0.84)	-25.04 (-0.76)
R ² (adjusted)	0.27	0.28

Notes: Cooking time includes all time spent in food preparation. Figures in parentheses are t-values. Ellipses indicate variables that are not included in the equation.

*Significant at the 0.05 level.

†Significant at the 0.10 level.

The results of the regression procedure show that additional amounts of cooking time across income groups significantly increase the ratio of rice calories to other calories (Table 19). In addition, the variables of child dependency, income per capita, and the ratio of lowland area to total area have significantly positive associations with the dependent variable, while the ratio of women's farm time to total farm time has a significantly negative relationship.

Taken together, the results of the two models above indicate that there is an indirect relationship between deforestation and diet composition.

Dietary Calories

Food consumption behavior in terms of total intake of calories is analyzed in this study to see if it is affected by changes in household income, its composition, adult literacy, and cooking time. Even though caloric intake is made up of a variety of foods, the demand for which can be altered by a change in income, the net effect is reflected in caloric or protein levels. Energy is a basic dietary requirement, a deficiency of which is felt as hunger. Therefore, to some extent, it may be said that people do purchase food for its calories, more perhaps than for any food component other than "taste," which is largely undefinable.³⁷

³⁷ Howarth Bouis, "An Agricultural Sector Model for the Philippines Identifying Localized Shortfalls in Household Food Security and Evaluating Policy Options Using Data from Ongoing Quarterly Surveys," a paper presented at a workshop of the International Food Policy Research Institute-Food Studies Group, Oxford, England, July 7-9, 1987.

Table 19—Effects of cooking time on cereal composition of the diet

Variable	Ratio of Rice Calories to Cereal Calories
Intercept	0.034
Cooking time	0.0003† (1.80)
Age dependency	0.09† (1.70)
Income per capita	0.00005* (3.37)
Ratio of lowland area to total area	0.55* (5.58)
Ratio of women's farm labor to total farm labor	-0.54* (-3.18)
Household size	0.01 (1.34)
R ² (adjusted)	0.48

Notes: Cooking time includes all time spent in food preparation. Figures in parentheses are t-values.

*Significant at the 0.05 level.

†Significant at the 0.10 level.

There has been much debate in the literature on the size of the caloric response to income.³⁸ It has been observed that lower-income households and those with generally calorie-deficient diets have a higher income elasticity for caloric intake than the rest of the population. Nevertheless, income elasticities for more expensive foods are higher than those for calories, even for these households. In other words, people are likely to spend incremental income on more expensive food than on larger quantities of high-calorie but less appealing foods. Rural households, which generally expend more energy and therefore have higher requirements than urban households do, also have a higher level of caloric intake and a higher income elasticity for calories at all levels of intake and incomes than their urban counterparts. These findings suggest that, while households with inadequate consumption have a high propensity to consume additional calories, they are also buying taste. There have been some attempts to quantify the extent to which households buy taste rather than calories at different income levels, and the implications of this for diet quality, but there is still little known about this component of food demand.

Caloric consumption functions are estimated as follows:

$$\text{LCAL} = f(\text{LY}, \text{FY/Y}, \text{ADLIT}, \text{CPC}), \quad (10)$$

where

LCAL = log of calories per capita per day,

LY = log of total annual per capita household income,

³⁸ For a review of the debate on methods and results obtained for individual foods, overall food expenditures, and energy intakes, see Harold Alderman, *The Effect of Food Price and Income Changes on the Acquisition of Food by Low-Income Households* (Washington, D.C.: International Food Policy Research Institute, May 1986).

FY/Y = ratio of farm income to total income,

ADLIT = percent of literate adults in the households, and

CPC = women's cooking time divided by the number of household members.

The equation is estimated, first, for the total sample; second, for households for which preschool nutritional status is low for the year as a whole (average weight-for-age for four rounds of quarterly measurements is less than 80 percent of the standard); and third, for households for which preschool nutritional status is in the normal range, that is, more than 80 percent of the standard weight-for-age. This indicator combines both short- and long-term effects of malnutrition.

The results are shown in Table 20. The income elasticity for calories is 0.51 for the total sample, 0.57 for households with malnourished children, and 0.44 for the others. More than half the households had undernourished children, using the weight-for-age indicator. These households had a 20 percent lower per capita caloric availability than the rest of the households. The difference in terms of calories per adult equivalent was 12 percent. The relatively small difference in dietary calories between the two groups is consistent with the generally poor association between household food availability and child nutrition found in other studies.³⁹ The coefficient of farm income ratio is significant and similar for the three equations, as is the mean value for the ratio itself. Cooking time per capita is significant for the sample as a whole and in the subsample without malnourished children. Adult literacy in the present specification is not significant, but it has a positive sign in the total sample and in the sample with malnourished children.

These findings on the size of the income elasticity of dietary calories are consistent with those from other rural areas.⁴⁰ The differences in dietary calorie elasticities between those households with malnourished children and those without are noteworthy. As mentioned earlier, similar differences are found when households are grouped by low and high levels of caloric intake. They indicate a significantly higher propensity to increase dietary calories among households where less food is available. Finally, on the income effect, the farm income component appears to be responsible for most of the income effect on consumption. This is a reflection of the strong orientation to subsistence agriculture of households in which own-production contributes the major part of the diet. The relationship between household dietary intake and child nutrition will be analyzed in the next section.

Time spent on cooking by women, weighted by the number of household members, is a significant factor in the level of dietary intake only for those households with higher income, higher calorie intake, and higher nutritional levels, suggesting that at lower

³⁹ See, for example, Eileen T. Kennedy and Bruce Cogill, *Income and Nutritional Effects of the Commercialization of Agriculture in Southwestern Kenya*, Research Report 63 (Washington, D.C.: International Food Policy Research Institute, 1987); Howarth Bouis and Lawrence Haddad, "A Case Study of the Commercialization of Agriculture in the Southern Philippines: The Income, Consumption, and Nutritional Effects of a Switch from Corn to Sugar Production," International Food Policy Research Institute, Washington, D.C., 1988 (mimeographed); and Joachim von Braun, David Hotchkiss, and Maarten Immink, "Nontraditional Export Crops in Traditional Smallholder Agriculture: Effects on Production, Consumption, and Nutrition in Guatemala," International Food Policy Research Institute, Washington, D.C., 1988 (mimeographed).

⁴⁰ Ibid.

Table 20—Factors influencing dietary calories

Independent Variable	Sample Mean	Total Sample	Sample Mean	Households with Malnourished Children	Sample Mean	Households Without Malnourished Children
Intercept	...	2.77	...	2.36	...	3.29
Log of total household income (annual Rs/capita)	1,970	0.51** (10.29)	1,684	0.57** (7.12)	2,287	0.44** (6.82)
Farm income ratio	0.75	1.02** (7.83)	0.74	0.99** (5.20)	0.76	1.03** (5.75)
Cooking time	0.62	0.33** (2.88)	0.59	0.13 (0.65)	0.64	0.41** (2.97)
Adult literacy (percent of literate adults)	42.4	1.25 ⁻⁰³ (1.07)	42.2	1.91 ⁻⁰³ (1.18)	42.6	-5.06 (0.3)
R ² (adjusted)	...	0.66	...	0.67	...	0.63

Notes: Households with malnourished children are those with average weight-for-age of preschool children less than 80 percent of the standard over four quarterly measurements. The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutritional Impact* (Geneva: WHO, 1979). Figures in parentheses are t-values. Ellipses indicate a nil or negligible amount.

**Significant at the 0.01 level.

income levels, where the bulk of the nutrition problems are likely to be, it is the time spent on production activities that appears to be the primary limiting factor. It was shown earlier that even though the marginal product of labor for the small farm households is as high as that for larger farms, their time spent on production is lower than that on larger size farms. Could it be that the poorer level of nutrition of the working population is a contributing factor in the time allocation pattern of the smaller farm households? This question is outside the scope of this report. The implication here is that for all households, food consumption is adversely affected by deforestation because additional collection time detracts from food production activities. This is especially pronounced for the low-income households with smaller farms. For the rest of the households, production time is a less significant factor, but time spent in other essential consumption-related activities, such as cooking, becomes increasingly important.

Effects on Nutritional Status

Nutritional status of all household members is assessed using heights and weights measured quarterly over the survey year. For children up to 18 years, the World Health Organization (WHO) growth standards for international use are used to determine those who are below the expected growth curve distributions.⁴¹ This section examines the nutrition situation of children in the study area and some of the main determinants that are of relevance in the present study.

Anthropometric measurements for two age groups, children less than 6 years, designated as preschoolers, and those 6-18 years old, are shown in Tables 21 and 22. For children less than 6 years old, results are compared with those of the 1975 Nepal Nutrition Survey. Both low weight- and height-for-age are more prevalent in the present

⁴¹ World Health Organization, *Measurements of Nutritional Impact* (Geneva: WHO, 1979).

Table 21—Anthropometric measurements for preschool children in 1975, Western Region, and in 1982/83 in study area

Measurement	1975 Survey	Total of Sample Observations	Syangja District, Bagkhor Panchayat		Tanahun District, Manapang Panchayat		Gorkha District, Chhoprak Panchayat	
			Ward 2	Ward 8	Ward 5	Ward 8	Ward 1	Ward 7
			(percent)					
Weight-for-age								
More than 75 percent of standard	51.4	48.9	33.0	50.8	64.8	30.4	72.4	41.2
60-75 percent	44.8	39.8	51.0	40.0	25.0	53.9	25.0	44.1
Less than 60 percent	3.8	11.3	16.0	9.2	10.2	15.7	2.6	14.7
Height-for-age								
More than 90 percent of standard	44.9	33.6	28.0	40.0	56.7	19.1	31.9	30.7
85-90 percent	36.8	35.1	36.0	23.1	22.8	41.6	44.8	35.7
Less than 85 percent	18.4	31.3	36.0	36.9	20.5	39.3	23.3	33.6
Weight-for-height								
More than 90 percent of standard	60.5	69.1	61.0	67.7	75.0	61.8	88.0	60.8
80-90 percent	34.1	22.6	26.0	24.6	15.9	28.1	10.3	30.1
Less than 80 percent	5.4	8.3	13.0	7.7	9.1	10.1	1.7	9.1
Less than 85 percent of height-for-age with less than 80 percent of weight-for-height	3.7	6.2	9.0	6.2	5.7	6.7	1.7	7.7

Sources: 1975 results for the Western Region are taken from U.S. Agency for International Development, Office of Nutrition Development Support Bureau, *Nepal Nutrition Status Survey, January-May 1975* (Washington, D.C.: USAID, 1975); those for the sample observations for this study are from Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Notes: Preschool children includes children from 6 months to 6 years of age. The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979).

Table 22—Anthropometric measurements for children 6-18 years old, 1982/83, study area only¹

Table 22—Anthropometric measurements for children 0-10 years (continued)							
Measurement	Total of Sample Observations	Syangja District, Bagkhor Panchayat		Tanahun District, Manapang Panchayat		Gorkha District, Chhoprak Panchayat	
		Ward 2	Ward 8	Ward 5	Ward 8	Ward 1	Ward 7
(percent)							
Weight-for-age							
More than 75 percent of standard	17.4	3.3	26.2	25.8	0.1	22.7	11.4
60-75 percent	46.3	37.4	47.5	46.8	53.0	53.9	37.7
Less than 60 percent	36.3	59.3	26.3	27.4	37.9	23.4	50.9
Height-for-age							
More than 90 percent of standard	22.3	6.6	28.7	66.1	21.2	26.9	14.0
85-90 percent	36.0	41.8	31.3	29.0	31.8	43.3	40.4
Less than 85 percent	41.7	51.6	40.0	4.9	47.0	29.8	45.6
Weight-for-height							
More than 90 percent of standard	75.6	48.3	86.2	85.5	81.8	83.7	60.6
80-90 percent	21.2	45.1	10.0	13.7	15.9	14.9	33.3
Less than 80 percent	3.2	6.6	3.8	0.8	2.3	1.4	6.1
Less than 85 percent of height-for-age with less than 80 percent of weight-for-height	2.0	5.5	2.5	0.0	2.3	0.0	3.5

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations, and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979).

study than in the earlier one. About 11 percent are severely underweight for age and more than 8 percent are severely underweight for height. This compares with about 4 and 5 percent respectively for the 1975 survey. Low height-for-age is found in 31 percent of the children observed in this study compared with 18 percent in the earlier one. These figures suggest a somewhat higher level of malnutrition than in the earlier period. Though similar standards were used in both surveys, it is not clear whether the differences are due to sampling differences, or if there has been a decline in nutritional status since the time of the earlier survey. Assuming that no major measurement problems were involved in either of the surveys and that the sample from the national survey was representative of the area, the evidence could lend support to the secular decline hypothesis. This conclusion is also supported by a somewhat larger average landholding size reported for this sample than the average figures for the area. No comparable figures from the earlier period for the older children are available. Although wasting (low weight-for-height) is less prevalent in the older group, weight-for-age and height-for-age indicators suggest that there is continued slow growth and no evidence of catch-up growth.

In order to examine the factors associated with child malnutrition, two probit models are estimated for the age group below six years.⁴² The two dependent variables are low height-for-age—an indicator of longer-term malnutrition—and low weight-for-height—an indicator of short-run malnutrition. The dependent variable is equal to 1 if the child's nutrition is in the normal range and 0 if malnourished. The cutoff points used are 90 percent of the WHO reference height-for-age and 95 percent of the reference weight-for-height.

Explanatory variables for child nutrition are based on household income, agricultural characteristics, household size, ethnic characteristics, relative work load of women in agriculture, the amount that older children work in collection and agricultural activities, and deforestation. These characteristics are expected to influence the direct determinants of nutritional status such as the household's and children's diets and time available for child care. The ethnic variable is introduced to capture differences, if any, between the Tibeto-Burman and the Newar-Brahmin groups. Two of the six sites were exclusively of Tibeto-Burman extraction, while the rest were from the Newar-Brahmin groups. The deforestation variable is expected to capture the combined effects via the time allocation and agricultural productivity effects that have been found to be associated with it. The variable on children's work load is included because if older children are extensively engaged in work, less child care may be available for the younger children. A similar interpretation may be made for the share of women's work load in agriculture. Household income and landholding are expected to influence nutritional status via their impact on diets, quality of housing, health, water supply, and sanitation. These indicators may also be expected to be associated with the level of education of household members.

The equation estimated is

$$NS = F(Df, HS, Y, Tcrl, ETHNIC, WR, ChL), \quad (11)$$

where

NS = height-for-age more than 90 percent of the reference and weight-for-height more than 95 percent of the reference are 1; others are 0;

⁴² In this model the dependent variable represents the probability of overcoming low nutritional status.

- Df = deforestation (wards where time per trip is high are 2, others are 1);
- HS = household size;
- Y = household income (in annual rupees per capita);
- Tcrl = total cropped area (in hectares);
- ETHNIC = ethnic group (Tibeto-Burman groups are 1, others are 0);
- WR = women's share of household labor in agriculture; and
- ChL = time spent by older children in collection activities, grazing of cattle, and agricultural production (in hours per day).

The results indicate that for preschool children, the longer-term nutrition indicator, height-for-age, is positively influenced by increasing per capita income in the household, even though the size of the coefficient is small and is negatively influenced by increasing household size (Table 23). Deforestation has a significantly negative influence on this nutritional status indicator. The more time spent by children working in collection activities, livestock grazing, and field work, the lower the level of nutrition of their preschool-age siblings.

Another indicator of nutritional status uncovered in the study is the ethnic background of the children. The ethnic groups classified as Tibeto-Burman in the sample appear to be taller than would be expected for people of their group using the height-for-age indicator after controlling for household income and other characteristics.⁴³ The others, which are largely from the Newar and Brahmin groups, would normally be taller, but they clearly rated below the Tibeto-Burman groups on this indicator. The reasons for the anomaly are unclear, but a future study might examine the effects of cultural differences in the area on nutritional status.

Poor nutritional status of preschoolers in the short term, as reflected in their weight-for-height, is also found to be significantly associated with deforestation, with high deforestation areas showing reduced weight-for-height. The ethnic group variable showed a similar result as the height-for-age equation, with the Tibeto-Burman groups having better child nutrition. Overall, the degree of predictability of weight-for-height is relatively lower than that of height-for-age. The time allocation variables—relative women's work load and degree of work involvement by older children—are found to be negatively associated with preschoolers' weight-for-height.

The results point to five main observations: first, high deforestation areas have poorer child nutrition when controlling for other household characteristics; second, household income is positively associated with good long-term nutrition indicators for preschool children; third, household size has a significantly negative effect on the longer-term nutrition indicator, height-for-age, but is insignificant for short-term nutritional status; fourth, the ethnic groups classified as Tibeto-Burman have better child nutrition than other groups; and fifth, the degree of involvement of older children in collection, grazing, and agricultural activities is negatively associated with child nutrition, and so, less significantly, is the relative workload of women in agricultural production.

⁴³ The Tibeto-Burman groups in the sample were Gurungs and Magars. These ethnic groups usually reside at higher altitudes in the hill and mountain regions of Nepal and are usually shorter than the Newar and Brahmin groups.

Table 23—Determinants of preschool children's nutritional status (probit model)

Variable	Height-for-Age	Weight-for-Height
Intercept	1.92 (1.53)	2.14* (2.01)
Household size	-0.25** (2.77)	...
Household income (Rs./person/year)	0.0005** (2.83)	...
Total cropped area (hectares)	0.27 (1.63)	0.15 (1.25)
Ethnic group (Tibeto-Burman = 1, other = 0)	1.34** (3.34)	0.76* (2.33)
Deforestation (high = 2, low = 1)	-0.92* (2.43)	-0.68* (2.09)
Ratio of women's agricultural work	...	-2.22 (1.59)
Children's work (hours/day)	-0.29* (2.08)	-0.17 (1.46)
Significance of χ^2	0.89 ^{E-06}	0.39 ^{E-01}

Notes: Figures in parentheses are t-ratios. The ellipses indicate t-ratios less than 1. Preschool children include those from 6 months to 6 years old. Cutoff points for probit analysis for preschool children are 90 percent of the standard height-for-age and 95 percent of the standard weight-for-height. The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979).

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Implications for Area-Level Programs

The results of this analysis indicate that overall there are strong possibilities that a labor constraint, especially of women's labor, is limiting the production and consumption potential in the area and that deforestation further aggravates this problem. In terms of policies and programs to alleviate the problems, this suggests that the payoff from labor-saving technologies for women, in conjunction with production technologies that raise labor productivity, could be high. Labor-saving technologies would be especially relevant if desired agricultural improvements require an expansion of labor input in production and postharvest processing. Labor-saving technologies for women would also benefit the nutrition of preschool children.

However, within an area, there is the potential for several alternative types of constraints to be present for different households. Where there is a significant labor constraint, there are also likely to be a number of farmers who face a land constraint and who would benefit from an increase in off-farm activities or from the opportunity to increase productivity from their land. Therefore, characteristics in the study area were examined to identify areas and households with different types of constraints to assist area planners in deriving an appropriate development package for different localities. Whereas for most areas inputs for increasing crop yields are desirable, it is also necessary to consider labor-saving technologies for labor bottlenecks, including those created by essential activities such as collection of fuel, fodder, or water, or food processing.

Another aspect of area-level programming is the issue of targeting publicly subsidized inputs and services. It has been widely acknowledged that, unless agricultural technology and input delivery institutions explicitly consider the needs of small farmers, benefits are likely to reach only a few well-off farmers in the initial stages of adoption of new technology or when there is a scarcity of these inputs and services.⁴⁴

In keeping with the previous arguments, it is considered desirable to examine the characteristics of nutritionally at-risk households to facilitate the targeting of alternative program components to them. In order to identify these households, several alternative criteria could be used. It is generally accepted that preschool-aged children form the most vulnerable segment of the population. However, older children represent a considerable opportunity for catch-up growth, and nutrition of the working-age population has direct productivity implications with indirect consequences for other household members. Thus, nutrition of all household members is relevant in its own way. In order to test which single indicator is positively correlated with various nutritional status indicators for all other groups, a simple test is conducted using all three (height-for-age, weight-for-age, and weight-for-height) for children below 6 years old and children 6-18 years old and the weight-for-height measure for adult men.⁴⁵ The results, shown in Table 24, indicate that adult men's weight-for-height is positively correlated consistently with all indicators of the younger age groups. Whereas preschool children's nutritional status is positively correlated with men's weight-for-height, it is not correlated with the nutritional status of older children. Based on these results, and also because about 30 percent of households did not have any preschool-aged children, men's weight-for-height is used as the criterion for selecting at-risk households.

Table 24—t-values for differences in anthropometric measures for alternative nutritional indexes

Anthropometric Measure	Nutritional Index		
	NSTAT 1	NSTAT 2	NSTAT 3
Children less than 6 years old			
Height-for-age	3.8	-0.8	1.6
Weight-for-age	8.0	0.6	1.7
Weight-for-height	5.8	2.4	1.7
Children 6-18 years old			
Height-for-age	-0.4	-0.6	1.4
Weight-for-age	1.5	4.3	3.1
Weight-for-height	0.1	3.8	1.4
Adult			
Weight-for-height (males)	1.8	0.5	12.3

Notes: Anthropometric measures are given as a percentage of the standards recommended in World Health Organization, *Measurements of Nutrition Impact* (Geneva: WHO, 1979). NSTAT 1 is households with children 6 months to 6 years old who are less than 80 percent of weight-for-height and 85 percent of height-for-age. NSTAT 2 is households with children 6-18 years old who are less than 80 percent of weight-for-height and 85 percent of height-for-age. NSTAT 3 is households with adult males who are less than 80 percent of weight-for-height.

⁴⁴ See G. Goodell, "Bugs, Bunds, Banks, and Bottlenecks: Organizational Contradictions in the New Rice Technology," *Economic Development and Cultural Change* 33 (October 1984); and Peter B. R. Hazell and C. Ramasamy, *Green Revolution Reconsidered: The Impact of High-Yielding Rice Varieties in South India* (Baltimore: Johns Hopkins University Press for the International Food Policy Research Institute, forthcoming).

⁴⁵ The measure for adult women could not be used because records of their physiological status were inadequate.

Within the at-risk group thus selected, three main subgroups are identified using principal components analysis.⁴⁶ These are land deficit, labor deficit, and excess livestock. Based on these earlier results, cut off points for these indicators are defined as less than 0.2 hectare (4 *ropani*) of land per capita, household size-to-worker ratio greater than 1.3, and less than 0.25 hectare per livestock unit kept by a household.⁴⁷ Generalizing from these results to the entire population, it is possible to identify a total of eight groups with various combinations of constraints. These are indicated in Table 25. From the prevalence of different constraints, the three district samples in the study, as represented by the *panchayats* of Bagkhor, Manapang, and Chhoprak, show a differing pattern of constraints. In Bagkhor, there is predominantly a land constraint, with smaller degrees of excess livestock and labor constraints. In Chhoprak, there is mainly a labor constraint, again with smaller degrees of excess livestock and land constraints. In Manapang, there is predominantly an excess of livestock, with no land constraint and some labor constraint. In this case, a secondary labor constraint may arise from the need for additional labor for grazing of livestock or for fodder and grass collection.

In predominantly land-constrained areas, deforestation is likely to be more severe in that area-expansion possibilities are probably minimal. Whereas intensification of input use to raise agricultural productivity in such areas is clearly indicated, indirect labor bottlenecks may also exist because the labor demand for collection activities is high. In the Bagkhor area, however, collection time was relatively low because the planting of private trees for fuel and fodder was expanded. Agroforestry efforts are most likely to succeed in such areas. Other areas, where landholdings are more adequate but labor is constrained, are likely to face ongoing deforestation. In these cases, input use should be intensified to stem further area expansion, especially on steeper slopes. Here tackling labor bottlenecks and intensifying input use in agriculture should both be integral parts of a program to improve production and consumption potentials of households.

Finally, some of the production characteristics of different household types and locations are examined in order to determine where improvements may best be made and the kinds of programs that may be adopted. In order to simplify the tabulation of all observations, the eight original household types are regrouped into four. In this process, livestock numbers in excess of cultivated land capacity are assumed to add to the labor requirement. If there is no existing labor constraint, then this type of constraint is not dropped from consideration. The new types are N1, which has both land and labor constraints (former types 1 and 3); N2, which has a land constraint only (former types 2 and 4); N3, which has a labor constraint only (former types 5 and 7); and N4, which has neither land nor labor constraints (former types 6 and 8).

The crop production characteristics of each of these four groups are shown in Tables 26 and 27. Overall, N2 households—those with only a land constraint—achieve the best production picture. They have the lowest amount of land under each crop but the highest yields and the largest amounts of household and wage labor inputs, fertilizer, and animal labor. Nevertheless, their annual per capita incomes are low. It is N3 households—those with a labor constraint—that have the lowest average production performance in terms of yields, labor, and fertilizer inputs. But because they have the largest amount of land under cultivation, they achieve the highest level of farm produc-

⁴⁶ Food and Agriculture Organization of the United Nations/Nepal, Agricultural Projects Services Center, *District Planning Manual for Nepal* (Kathmandu: APROSC, 1984).

⁴⁷ Food and Agriculture Organization of the United Nations/Nepal, Agricultural Projects Services Center, *District Planning Manual for Nepal*.

Table 25—Types of household constraints possible

Type of Constraint	Landholding Less Than 0.2 Hectares Per Capita	Household Size- to-Worker Ratio More Than 1.3	Landholding Less Than 0.25 Hectares Per Livestock Unit
1	X	X	X
2	X	...	X
3	X	X	...
4	X	...	...
5	...	X	X
6	...	...	X
7	...	X	...
8	...	...	...

tion and household per capita income. The N1 households—those with both land and labor constraints—have an average-to-low production picture and are not able to achieve the productivity levels of N2 households, which also have a land constraint but no labor constraint. Both types of land-constrained households have more migrant workers and income from remittances.

Table 26—Agricultural production by type of constraint, by major crops, 1982/83

Constraint Type/Crop	Number of Households	Area	Yield	Total Family Labor	Total Wage Labor	Total Labor
		(hectares)	(kilograms/ hectare)		(days/hectare)	
Type N1 ^a						
Wheat	14	0.37	987	155	18	173
Maize	32	0.49	1,078	146	15	161
Ragi	31	0.33	781	259	15	274
Paddy	26	0.35	1,857	266	49	315
Type N2 ^b						
Wheat	13	0.13	1,322	234	16	250
Maize	24	0.42	1,169	196	35	231
Ragi	23	0.30	987	353	13	366
Paddy	19	0.32	2,058	285	49	334
Type N3 ^c						
Wheat	16	0.47	825	137	31	168
Maize	31	0.74	1,082	147	33	180
Ragi	25	0.54	956	234	17	251
Paddy	28	1.05	1,951	254	54	308
Type N4 ^d						
Wheat	10	0.47	929	141	12	153
Maize	26	0.99	1,447	200	32	232
Ragi	25	0.72	1,176	314	14	328
Paddy	24	0.86	1,612	282	40	322

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

^a Type N1 has both land and labor constraints (N = 33).

^b Type N2 has a land constraint only (N = 26).

^c Type N3 has a labor constraint only (N = 31).

^d Type N4 has no land or labor constraint (N = 28).

Table 27—Household characteristics by type of constraint, 1982/83

Household Characteristic/ Unit of Measure	Type of Constraint			
	Land and Labor (N1)	Land Only (N2)	Labor Only (N3)	No Land or Labor Constraint (N4)
Household size (average number)	6.9	5.7	6.6	7.1
Adults (working age)	2.8	3.4	2.8	4.7
Children (up to 15 years)	3.8	2.1	3.5	2.2
Migrant workers (number)	0.6	0.6	0.4	0.4
Land cultivated (hectares)				
Upland area	0.5	0.4	1.1	1.3
Lowland area	0.3	0.3	1.0	0.9
Cropping intensity (percent)				
Upland intensity	159	169	141	143
Lowland intensity	170	156	167	157
Livestock units	4.9	5.7	8.1	9.3
Annual total income (Rs/capita)	1,421	1,427	2,573	2,394
Farm production	715	654	1,813	1,765
Employment	171	133	85	72
Remittances	382	442	138	323
Farm by-products	166	215	403	257
Food consumption				
Calories (per capita/day)	1,431	1,758	2,926	2,449
Protein (grams/capita/day)	41.8	50.4	78.7	68.5
Anthropometry (percent of children)				
Children less than 6 years				
Less than 85 percent height- for-age and less than 80 percent weight-for-height ^a	8.6	5.8	4.6	4.2
Children 6-18 years				
Less than 85 percent height- for-age and less than 80 percent weight-for-height ^a	4.8	1.0	0.0	1.0

Source: Nepal, Agricultural Projects Service Center; the Food and Agriculture Organization of the United Nations; and International Food Policy Research Institute, "Nepal Energy and Nutrition Survey, 1982/83," Western Region, Nepal.

Note: The anthropometric standards used in this study are those recommended in World Health Organization, *Measurements of Nutritional Impact* (Geneva: WHO, 1979).

^a This measurement combines stunting and wasting to indicate both long- and short-term malnutrition.

Though their overall income levels are comparable, both food consumption and child nutrition levels are significantly lower for N1 households, which may be attributed to the higher work load of adults. In addition, the nutrition of the 6-18 year olds is the worst in this group, perhaps because their work load may also be high. This age group does best in N2 households, which may also be linked to their relative work loads. Also, preschool nutritional status for N2 households is closer to that of the higher-income N3 and N4 households.

Thus, it is N1 and N3 households that need improvement, both in production and nutrition. These are essentially labor-constrained households, either with or without a land constraint. Deforestation would further exacerbate the situation for the groups that are worst off.

CONCLUSIONS AND POLICY IMPLICATIONS

The area described in this report is typical of the hill areas of Nepal, which are characterized by low levels of agricultural productivity, limited adoption of new technology, and a high rate of natural resource degradation, particularly deforestation. The study area is typical of many rural areas that have been bypassed by improvements in agricultural technologies and related benefits during the past two decades. However, in one respect it may be quite different. The pace of deforestation here has direct repercussions on the vast foodgrain belt of the plains. The evolution of a sustainable and stable agriculture in the hill areas may be, therefore, necessary for the welfare of more than these areas alone.

A policy prescription for such areas is simply to leave things alone, using them as a reservoir for out-migrating labor and letting remittances into the area provide the means to an effective demand for the inflow of food and other products needed to maintain their standard of living. Despite high out-migration—an average of one migrant worker for every two households—remittances have so far been small and have not contributed to raising food consumption of the households. This may change when the workers return, either with accumulated savings or retirement pensions. Alternatively, efforts in recent years have focused primarily on reforestation and other measures designed to preserve the natural resource base.

These approaches alone, however, are inadequate. Bajracharya has argued persuasively that it is initially the low productivity of agriculture in these areas that promotes deforestation.⁴⁸ According to his analysis, the inability to provide for food needs from the returns to agriculture provides an incentive for increasing land under cultivation. The results confirm that agriculture in the area is highly dependent on labor, and there is increasing competition between productive and other uses for labor, possibly contributing to inefficient methods of collection of forest products, primarily fuelwood. (For example, concentrating collection efforts on the most accessible forest, rather than spreading out the collection efforts, can promote rapid deforestation, despite the overall adequacy of forest resources in the region as a whole.)

In other words, the low agricultural productivity derived from a high dependence on human labor contributes to the relatively higher population pressure on arable land and to the erosion of the natural resources that are essential for maintaining the production base.⁴⁹ Clearly, a vital question in this context is whether the introduction of improved agricultural technologies in this area will reduce or increase the pressure on land and the encroachment on forest lands. Most likely the answers will differ depending on the crops and type of technologies promoted, the institutional setup used to make them available to smallholders, the pace of infrastructure development in the region that can help to channel resources to the off-farm sector, and the presence of forestry and related efforts.

⁴⁸ Bajracharya, "Fuel, Food, or Forest?"

⁴⁹ Consultative Group on International Agricultural Research, Technical Advisory Committee, *Sustainable Agricultural Production*.

Results of this study suggest that deforestation has adverse effects on agricultural production, food consumption, and nutrition that occur as a result of the additional work loads entailed in the collection of essential forest products on which the households depend, primarily fuelwood, fodder, and grass. In the longer run, water availability for both household and irrigation purposes could also be affected. The adverse effects on irrigation potential will of course be far-reaching geographically.

Women, in particular, have a high and increasing work load as deforestation expands, and this burden reduces labor in agriculture. Limited availability of labor and low substitutability between women's and men's labor can lead to a much larger overall decline in labor input in agriculture with deforestation. This is a seldom acknowledged factor in the decreasing agricultural productivity of hill agriculture, where the high rate of out-migration has usually been interpreted as a sign of an underutilized work force, when instead it is the low returns to labor in agriculture that encourages out-migration. The evidence indicates that deforestation is directly and indirectly linked with levels of food consumption and nutrition for the households.

The following observations have emerged from this study:

- Deforestation, which represents a 1 percent increase in time spent for collection of a unit of fuelwood, leads to a reduction in fuel consumption of 0.3 percent but an increase in the total time required for collection of 0.6 percent.⁵⁰
- The sites in the study sample where deforestation is extensive require 75 percent more time spent for collection per load of fuelwood, which suggests a 45 percent increase in total collection time. With a similar response for other forest products that are collected on a regular basis, such as fodder and grass for animals, and assuming that men, women, and children increase their time in proportion to their existing time allocation, women would need an additional 1.13 hours per day to collect these products. This estimate is consistent with the increases in actual time spent by women.
- Estimation of the change in household labor supply to agriculture, given the above magnitude of deforestation, shows a reduction in women's field labor of about 1.5 hours per person per day. Further, this reduction is accompanied by a reduction in men's agricultural labor of about 0.8 hours per person per day. As a result, household labor per hectare decreases by about 40 percent in high deforestation areas. The small increase in wage labor that occurs does not compensate for the reduction in household labor input.
- Estimates of physical production functions show the significance of labor input in crop output. Women's labor has the highest marginal product for dry-season crops. On a seasonally adjusted basis, the dry season is also when more time has to be spent on collection of forest products. This suggests that there are losses in agricultural productivity and real income with time allocation patterns that accompany deforestation. This is likely to be only partly offset by higher seasonal out-migration and income from such employment.
- Food consumption, in terms of caloric consumption and the ratio of rice calories to cereal calories, is a significantly positive function of household income (the

⁵⁰ All figures are based on quarterly surveys, which have been aggregated to represent time allocation on an annual basis.

farm income component is the only statistically significant component) and food preparation time. Food preparation time, however, is a positive function of fuelwood used and a negative function of the total collection time, suggesting these factors may also influence food consumption via less time spent on cooking and food preparation. This is in addition to the effect of deforestation on agricultural production and hence on household farm income.

- Preschool child nutrition is improved by raising household income, and it is lower in areas with higher levels of deforestation. An increase in household size and in children's work is also associated with inadequate nutrition of preschool children. Controlling for other household characteristics, the Tibeto-Burman ethnic groups have better child nutrition than other groups.
- An examination of the characteristics of the nutritionally at-risk households confirms that these are more likely to be labor constrained than land constrained, and they have lower levels of agricultural productivity.

The results clearly show that under current productivity, households continually need to expand cultivated area. To the extent that this contributes to deforestation, this expansion reduces household income, food consumption, and nutritional status. Under these circumstances, relying only on out-migration in these areas is unlikely to improve living conditions or stem the environmental degradation through deforestation. It is also questionable whether reforestation efforts by themselves will suffice, though this would be a useful question to examine empirically. In the past, settlement schemes in the tarai have drawn a fair share of settlers from the hill areas. But if deforestation continues at the present scale, en masse movement of population from the hills may occur at some future point in time. It seems evident that there is a need to increase agricultural productivity, preferably on soils that are better endowed. This would contribute to improvements in household welfare and reduce deforestation.

Another policy option that has frequently been proposed for the development of these hill areas is the growth of horticulture production.⁵¹ The rationale stems from both the agroclimatic characteristics of the hill regions of Nepal and the poor road transport facilities that prevail. Products with high value to weight are consequently appealing. An IFAD study recommends the following steps be taken: a comprehensive ecological classification of areas for production of specific horticultural products, a survey of national and international markets, a research program focused on selected species, human and physical capital development to support the extension effort, research on desirable processing technologies, and support of commercial enterprises for setting these up.⁵²

For smallholders' horticultural production to be successful would require not just an outlet where the products would be competitive with existing suppliers, but also an extremely efficient marketing system in the hills that would be readily accessible to the scattered smallholders and would avoid the high perishability inherent in marketing of horticultural products. Given the largely subsistence orientation of agricultural production at present in these areas, the degree of rural market development is too severely limited to be able to handle a large outflow of horticultural produce. Public marketing is probably not a good idea, as the degree of investment required and the

⁵¹ International Fund for Agricultural Development, *Report of the Special Programming Mission to Nepal* (Rome: IFAD, 1979), p.38.

⁵² Ibid.

relative inefficiency of this sector will likely lead to monopolistic tendencies that will be unproductive in the long run.

The issue of the need for efficient rural markets to handle the horticultural products is also related to the need to be competitive with the existing suppliers to the major metropolitan centers of the subcontinent, such as Kathmandu, New Delhi, Calcutta, Islamabad, and others. These centers already have a well-established network of suppliers, so that products from the Nepal hills would have to be produced very cheaply, or they would have to aim for the high price end of the horticultural products market. The latter option is probably preferable but will require many years of research on commodity and market development. Such an effort clearly needs to begin.

In the meantime, efforts for increasing productivity of traditional crops in hill regions need to continue. This is important not only for maintaining consumption without substantial area expansion, but also for promoting an expansion away from largely subsistence production. Production for the market should promote the growth of rural markets in the hill areas, providing the basis for the growth of a privately financed rural services infrastructure. The growth of such a base will facilitate the gradual shift into more specialized production of horticultural and livestock products.

The results of the study suggest that in order to increase agricultural productivity, a combination of efforts for increasing input use and reducing labor bottlenecks is necessary. These findings are consistent with the IFAD recommendation promoting the use of selected labor-saving technologies such as power tillers as an alternative to oxen for easing labor bottlenecks and for spreading employment on small farms more evenly.⁵³ These tillers are relatively inexpensive and simple to operate and maintain. They could also reduce demand for work oxen, thus reducing human labor needed for feed collection and grazing, and alleviating pressure on the environment. Other labor-saving technologies for improvement in operations such as food processing or water supply should also be explored, as well as agroforestry efforts that reduce collection time for forest products such as fuel and fodder.

⁵³ Ibid.

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RESEARCH REPORT



AGRICULTURE IN THE GATT: AN ANALYSIS OF ALTERNATIVE APPROACHES TO REFORM

Joachim Zietz
Alberto Valdés

November 1988

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FOOD
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The **International Food Policy Research Institute** was established in 1975 to identify and analyze alternative national and international strategies and policies for meeting food needs in the world, with particular emphasis on low income countries and on the poorer groups in those countries. While the research effort is geared to the precise objective of contributing to the reduction of hunger and malnutrition, the factors involved are many and wide-ranging, requiring analysis of underlying processes and extending beyond a narrowly defined food sector. The Institute's research program reflects world-wide interaction with policymakers, administrators, and others concerned with increasing food production and with improving the equity of its distribution. Research results are published and distributed to officials and others concerned with national and international food and agricultural policy.

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AGRICULTURE IN THE GATT: AN ANALYSIS OF ALTERNATIVE APPROACHES TO REFORM

**Joachim Zietz
Alberto Valdés**

**Research Report 70
International Food Policy Research Institute
in collaboration with the
Kiel Institute of World Economics
November 1988**

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FOREWORD

The Uruguay Round of multilateral trade negotiations under the aegis of the GATT provides a unique opportunity to move toward resolution of the crisis that has characterized international trade in agricultural products for some time. The outcome of the Uruguay Round may well set the framework for trade relations for years to come. The stakes in the negotiations are high, not only for industrialized countries, but in particular for developing countries. Security and predictability of market access, and stability of trade relations and international agricultural markets are of great importance to the economic growth of the food and agricultural sectors of developing countries as well as their overall economy.

The International Food Policy Research Institute has published several other studies on similar trade-related topics. These include an analysis of the international effect of Soviet grain imports and of European grain policies, the political-economy determinants of U.S. and European agricultural and trade policies, and an earlier quantitative study by Valdés and Zietz of the costs to developing countries of protectionist policies in OECD countries.

In a sense, the current study is a sequel to the authors' previous research report. Having established earlier the high costs of trade protectionism that characterize the current crisis in agricultural trade, they now offer a comprehensive conceptual analysis of the main ideas for trade reform in agriculture. As the Uruguay Round is now going into its second and decisive half, this report is particularly timely. Its careful analysis of numerous trade reform ideas using a common reference system offers the reader a much-needed orientation as well as a new perspective on the problems surrounding trade reform.

IFPRI is grateful to the Kiel Institute of World Economics and to its president, Herbert Giersch, for their generous support of this undertaking. We hope that this joint effort will advance the goals of the Uruguay Round and thus contribute to a better trading environment in agriculture.

John W. Mellor

Washington, D.C.
November 1988

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1

SUMMARY

Much trade in agricultural products is conducted under conditions that bear little resemblance to the letter or the spirit of the General Agreement on Tariffs and Trade (GATT). Nontariff barriers proliferate, export subsidies increasingly substitute for a natural competitive advantage, trade wars erupt with frightening regularity.

There is some hope that the Uruguay Round can achieve more for agricultural trade than prior GATT rounds. Sharply rising budgetary costs of national farm policies in recent years seem to have made the European Community (EC), the United States, and other industrial countries more open to the idea of agricultural trade reform than ever before. There is a danger, however, that diminishing budgetary pressures, which are the result of recently rising world prices and certain adjustments in domestic farm policies, could reduce the current momentum for reform. Piecemeal accommodation on a commodity-by-commodity basis could then be the outcome of the Uruguay Round. Although this might suffice to further stabilize government budgets, it would not bring lasting improvement. It is therefore important not to lose sight of the final objective of trade reform in agriculture: to establish an environment that is free of trade-distorting government interventions, fully integrated into the GATT, yet flexible enough to deal with domestic structural adjustment problems and income instability.

Not every reform proposal that is under current discussion is likely to ease the transition to this state of world trade. Some may make it actually impossible to ever get there. It is important, therefore, to analyze the properties of a given reform proposal before much time is spent on it during the trade negotiations. For that purpose, a number of criteria are developed to check (1) to what extent a given reform proposal is consistent with the final objective of trade reform, (2) whether the proposal has any practical value in day-to-day operations, and (3) whether it has the potential to win the approval of the main players in the Uruguay Round—the United States, the EC, the nonsubsidizing exporters united in the Cairns Group, and Japan.

When these criteria are confronted with actually proposed ideas for trade reform, it becomes clear that there is no single idea or element of trade reform that would satisfy all the criteria that are established. Yet there is some evidence that an appropriate combination of reform ideas might achieve this goal. One such combination would consist of two elements: a strict ban on export subsidies, and comprehensive tariffication.

The ban on export subsidies would eliminate the special treatment for agricultural, fishery, and forestry products in the General Agreement and the Subsidies Code. Tariffication consists of two components: the replacement of all unbound tariffs and nontariff barriers with bound base tariffs that are uniform across broad commodity groups for each country, and the extension of that change to the safeguard Article XIX of the General Agreement.

The bound base tariff represents the basic tariff concession of a country. It is the tariff level that a given country would apply uniformly across broad commodity groups, once the adjustment to a system based only on tariffs is completed. A country is bound to this tariff at all times unless it invokes Article XIX. Extending tariffication to Article XIX implies that safeguard measures are limited to temporary tariff increases. A revised safeguard Article XIX is envisioned to operate as follows. A country using a temporary tariff increase, or excess tariff for short, would bind itself to a timetable for lifting the safeguard measure. This timetable would specify the dates on which the excess tariff would be reduced to zero as well as the step size of the individual reductions. To avoid prohibitive tariffs the use of excess tariffs under the safeguard

article could be conditioned on some minimum-access provision similar in spirit to that currently written into Article XI:2(c). Article XI:2 could be rewritten so as to apply to all trade regardless of sector and whenever a country uses any import restriction other than its bound base tariffs.

The excess-tariff provision is envisioned as the major vehicle to eventually reach a system based only on bound, uniform tariffs. Excess tariffs would offer temporary import relief for all products that are currently protected by nontariff barriers with tariff equivalents far in excess of the uniform base tariff that a given country would adopt after the adjustment to the new system.

As excess tariffs are lowered over time, according to some fixed schedule, to the level of the bound base tariff, and as the resultant adjustment pressure grows, countries may resort to gray-area measures to reduce this pressure. Four types of gray-area measures to avoid the disciplines of tariffication are of particular interest in this context: voluntary export restraints, state trading arrangements, domestic subsidies, and exchange-rate manipulations.

The potential problem of voluntary export restraints could be contained by prohibiting them explicitly and, at the same time, giving the GATT Secretariat an active role in supervising this prohibition, including the right to initiate cases against a country that forces export-restraint agreements on its trading partners. Treating export subsidies in agriculture the same as in other sectors should go a long way toward eliminating implicit export subsidies by state trading enterprises in agriculture. Implicit quantitative import restrictions, in contrast, are more difficult to prevent. The only practical solution may be to restrict their operations on the import side indirectly through binding the nominal rate of protection for all those goods under their control. In particular, it could be stipulated that the price difference between the border price and the domestic wholesale price of products under the control of state trading enterprises should not exceed the equivalent of the bound base tariffs for those products.

As long as it is believed that domestic subsidies will not be a major issue under a system of relatively low uniform tariffs, it may be most efficient to resolve domestic subsidies issues on a case-by-case basis. This could be achieved either through negotiations outside the GATT or through dispute settlement inside the GATT. The latter would require, however, that the current dispute-settlement procedure be made more responsive. This is in the special interest of developing countries because they generally lack the necessary political or economic clout to settle subsidy issues (or other issues, for that matter) through direct negotiations outside the GATT. Attempts of governments to circumvent the disciplines of tariffication and an export subsidy ban through exchange-rate manipulations may be handled in the same way as domestic subsidies, that is, without adding new provisions to the General Agreement or to its subsidiary codes law.

Compared with alternative suggestions for trade reform (for example, fixing overall protection levels), the above package has a number of advantages. At its core, the reform proposal is not dependent on new policy instruments or measurement techniques that have not been tested. Rather, it relies on well-known GATT instruments and principles. Everything else being constant, this should ease rather than complicate the transition from the current state of trade in agriculture and other industries to the final objective of free trade. Trying to incorporate a completely new, untried approach such as the Producer Subsidy Equivalent into the GATT framework could not only cause the negotiations to deadlock over measurement concepts and problems, but would also have the negative side effect of firmly establishing a "special case" for agriculture rather than integrating this sector fully into the GATT system.

Whether a proposal such as tariffication has a realistic chance of being adopted during the Uruguay Round depends ultimately on its ability to garner enough domestic political support in the major trading nations. Domestic acceptability hinges on a favorable political constellation. It is particularly important that the political power of the groups that stand to lose from a trade-reform proposal in the short run be kept in check by a sufficient amount of counter-

vailing power. This means there have to be other special interest groups, apart from consumers, that are strongly in favor of a trade reform and, at the same time, have enough political influence to counter the efforts of those groups that oppose the reform.

Sector-specific, commodity-based reform proposals that lead to piecemeal trade arrangements for one commodity at a time do not generate the necessary countervailing power. Instead they maximize the influence of special interest groups on the negotiations at the expense of the interests of the whole country. The aggregate negotiating approach advocated by the United States in its reform proposal for agriculture fares somewhat better in generating countervailing power. It suggests that an agreement on all agricultural support programs be concluded in a single package. In this way the political influence of a commodity group that is losing can be counteracted by the influence of a commodity group that stands to gain. This negotiating approach runs into a problem, however, if there are countries with few or no commodity groups that expect to gain from a given reform package. Japan, some northern European countries, and, to some extent, the EC are likely to fall into this category.

The obvious solution is to negotiate in one package not only all of agriculture but all sectors, so that gains anticipated in industry can help to compensate for losses in agriculture or vice versa. Countervailing power would be established across sectors and industries. But just as a package deal in agriculture alone requires a unifying negotiation and measurement concept, so will negotiations across sectors necessitate a unifying principle. Tariffication as defined above could be this sought-after unifying theme or principle. It is applicable for all sectors and is fully compatible with the spirit of the GATT. It could replace the "across-the-board" tariff-reduction idea of the Kennedy and Tokyo rounds.

2

INTRODUCTION

Previous rounds of multilateral trade negotiations under the aegis of the General Agreement on Tariffs and Trade (GATT) have brought little substantive change to agricultural trade. Some observers even go as far as calling agriculture the GATT's greatest failure (Leddy and Reinstein 1987, 45). This conclusion is understandable in view of the crisis that has unfolded in agricultural trade over the past few decades. Its signs are all too familiar; for example, competition by export subsidies rather than comparative advantage, trade disputes over domestic subsidies, rising costs of farm support but falling incomes of farmers, and increasing uncertainty of market access for developing countries.

The Uruguay Round has set out to change this. In contrast to prior trade negotiations, agriculture now occupies center stage. In addition, the negotiations on agriculture have been better prepared than ever before. A Committee on Trade in Agriculture was set up within the GATT in 1982, four years before the beginning of the Uruguay Round, to identify promising reform proposals. Also in 1982, a ministerial meeting of the Organisation for Economic Co-operation and Development (OECD) commissioned a comprehensive study of national agricultural policies and their trade implications. Completed in 1987 (Organisation for Economic Cooperation and Development 1987), the study's intent is to provide a common denominator for the Uruguay Round negotiations among the industrialized countries. Finally, because of the rapidly rising budgetary costs of national farm policies, the European Community (EC), the United States, and other industrialized countries now seem more receptive to the idea of agricultural trade reform.

Commodity prices appear to be rising again after a long period of depression. At the same time, the United States and the EC have made a number of adjustments in their farm support programs to cut budgetary outlays on agriculture. Both events could bring some relief to agricultural commodity markets. However, they could also reduce the incentive to embark on a thorough reform of agricultural trade. Although accommodation on a commodity-by-commodity basis might further stabilize government budgets, it is unlikely to result in lasting improvement. It is therefore important to keep in mind the final objective of agricultural trade reform in the Uruguay Round: an environment without government interventions that distort trade, fully integrated into the GATT, yet with the flexibility to deal with domestic problems of structural adjustment and income instability.

With the Uruguay Round almost two years under way, it has become obvious that progress on agricultural trade is a far more complex problem than negotiating tariff reductions in manufactures. This is because, in most countries, government intervention in agriculture is much more pronounced than in any other industry or sector. The objective of these domestic interventions is to support and stabilize the income of farmers relative to nonfarmers. Many countries consider this to be an issue for domestic policy only. However, many domestic interventions are intimately tied to border measures with a strong trade-distorting effect. This linkage has serious consequences: without a willingness on the part of protecting countries to change the way they manage their domestic income-support programs for farmers, it is difficult if not impossible for them to negotiate on border measures, which happen to be the traditional focal point of multilateral trade negotiations under the aegis of the GATT.

The United States, the EC, the nonsubsidizing exporters united in the Cairns Group, and Japan are the main players of the Uruguay Round. The early part of the current round appears

to confirm the practice of the years leading up to this round: the main dividing line for agricultural policy and trade reform is located between the United States and the EC. Most major disputes in the field of agriculture have taken place between these two participants. The sheer size of their economies and their importance for agricultural trade implies that little progress will be possible without resolving their differences. The importance of these two players is reflected in this study, in that much of the analysis is spent on developing their likely responses to alternative reforms of agricultural trade and hence the structure of their domestic support programs.

In contrast, issues specific to developing countries, such as the question of reciprocity, trade preferences, and tropical products, are neither examined as separate topics nor do they occupy center stage.¹ But although the study does not revolve around these issues, this does not make it irrelevant to less developed countries (LDCs). On the contrary, concentrating on the broader aspects of agricultural trade reform makes it easier to reflect more sharply on the value to developing countries of such things as trade preferences, market access, and reciprocity than if they were discussed in isolation.

There is a final caveat the reader should keep in mind. It is not intended to present and discuss in detail all the various trade reform proposals either suggested in the literature, discussed by the Committee on Trade in Agriculture, or already tabled in the negotiating group on agriculture at the Uruguay Round meetings in Geneva. This would probably be a poor approach because of the sheer number of proposals, their sometimes imprecise statement, and their character as bargaining instruments. The preferred alternative is to break down the proposals into their main generic elements or ideas and to examine these. Examples of such elements that make up comprehensive trade reform proposals are further disciplining or banning export subsidies, providing exporters with minimum access to import markets, converting nontariff barriers into tariffs, and binding the overall protection level.

The analysis concentrates on the economic aspects of agricultural policy and trade reform. However, where appropriate, relevant political-economy considerations and implications are taken up. The analysis is conducted at a level that makes it comprehensible to the nontechnically inclined. Most of the analysis relies on verbal reasoning. Graphs are added where they help illustrate some more involved points.

The following chapter gives a brief overview of the current state of agricultural trade. It touches on the legal environment of the General Agreement, the extent and economic consequences of protectionism in agricultural trade, and the current status of the Uruguay Round negotiations. The subsequent chapter establishes the criteria to be used for discriminating among various ideas for trade reform. Next, these criteria are confronted with the major reform ideas under current discussion. The last chapter draws the conclusions from the prior analysis by combining a number of reform ideas into a trade reform package that both lives up to the criteria established earlier and is reasonably realistic.

¹ Interested readers are referred to the specialized literature: Hudec 1987; Finger and Olechowski 1987; and Valdés 1987. These studies contain a large number of further references that deal specifically with the problems of developing countries.

3

AGRICULTURE IN THE GATT: AN OVERVIEW

The Legal Background

Although the rules and regulations of the General Agreement apply in general to agriculture as they do to manufacturing, there are several significant exceptions. They relate mainly to the treatment of quantitative trade restrictions and export subsidies. (Of the GATT's 38 articles, only 4 contain special provisions for agriculture. These are Articles VI, XI, XVI, and XX. See Appendix 1 for a reprint of these and other articles referenced in this report.)

Articles XI to XIV and Article XIX of the General Agreement specify the rules for quantitative import restrictions. Of these, Article XIX provides a justification for quantitative import restrictions on all goods, not just primary goods, if surging imports are thought to harm domestic producers. Article XI is of particular interest to agricultural trade. Its importance derives from its exemption of primary goods, under certain circumstances, from the general prohibition of quantitative import or export restrictions established in the General Agreement. (Since the Tokyo Round, the primary goods category has included agricultural, fishery, and forestry products; before the Tokyo Round, it also included mineral products.) The circumstances justifying quantitative trade restrictions for agricultural goods are the prevention of or relief from shortages of food or other essential products; the enforcement of domestic marketing or production control programs, or the removal of temporary domestic surpluses; and the application of standards of commodity classification, grading, or marketing.

These special exemptions for agricultural and fishery products were incorporated into the original General Agreement in 1947 at the insistence of the United States. In their absence, several U.S. farm support programs that were in effect at that time would have had to be given up. The U.S. Congress, however, was unwilling to trade domestic farm support legislation in favor of a General Agreement without special rules for agriculture. Article XI was weakened even further in its relevance for agriculture in 1955, when the United States asked for and received a permanent exemption from the provisions of Article XI.² Since 1955 this exemption has been used at various times by the United States to justify quantitative import restrictions for dairy products, sugar, and beef. Even though the U.S. waiver may not have been important quantitatively, it has been of significance in a qualitative sense. By taking the bite out of Article XI for agriculture, it is likely to have contributed to a more lenient international trading environment. In this way the waiver has advanced the propagation of quantitative import restrictions, state trading, and gray-area measures such as voluntary export restraints.

Regarding subsidies, the GATT has undergone a number of changes since its creation. The treaty's initial version called upon countries applying subsidies only to give adequate notice to all affected GATT signatories. There were no provisions for outlawing subsidies altogether, regardless of whether they were intended to promote exports or address domestic policy objectives. This changed with the 1955 revision of the treaty, when three paragraphs (now XVI:2

² The U.S. request was the result of a congressional amendment of section 22 of the Agricultural Adjustment Act of 1933, which was passed after the GATT had found the United States to be in violation of Article XI for dairy products in 1951. The amendment of section 22 required the administration either to use import quotas to lower imports up to one-half the level of previous period imports or to impose excess ad valorem tariffs of up to 50 percent whenever domestic farm support programs were endangered.

to XVI:4) were added to the original subsidy article, thereby transforming its character.

The most important innovation of the 1955 revision of the General Agreement was the ban on export subsidies. Primary goods, however, were exempted from this general prohibition. Instead, a statement was included to the effect that export subsidies for primary goods should be avoided and that, if applied, they should not result in a more than equitable share of world trade.

The exemption of agriculture, along with fishery and forestry products, from the general ban on export subsidies can again be traced to the influence of the U.S. farm lobby. When the 1955 revisions of the export subsidy Article XVI were reviewed by GATT in 1958, the United States took the lead in defense of that article (Paarlberg 1987, 46). The U.S. position on the export subsidy issue changed only when it became clear in the 1960s, after the establishment of the EC's Common Agricultural Policy in 1962, that the provisions would be used to the detriment of the U.S. agricultural sector. However, no progress was made on the subsidy question either in the Dillon Round (1961-62) or the Kennedy Round (1963-67). In fact, both of those rounds achieved little for agriculture except some statutory tariff reductions.³

During the Tokyo Round of multilateral trade negotiations (1973-78) the United States championed, with some success, an effort to further restrain the spreading use of trade-related subsidies. A Subsidies Code was added to the General Agreement.⁴ (Articles 8 through 13 of the Subsidies Code, as well as its Annex with an illustrative list of export subsidies, are reprinted in Appendix 2 of this report.) Strictly supplementary to the General Agreement, and binding only to its signatories, the Subsidies Code widened the definition of "more than equitable share" of the world market to cover the displacement of exporters in third-country markets. In addition, some other provisions of Article XVI were somewhat sharpened, and a dispute-settlement mechanism was put in place to enable signatories to enforce their rights under the Subsidies Code. (See Articles 12 and 13 of the Subsidies Code. A thorough discussion of the dispute mechanism can be found in Hudec 1978.)

Only about a quarter of the GATT members have signed the Subsidies Code. It appears that this code is among the least effective of those negotiated during the Tokyo Round. A lack of consensus on the wording and interpretation of the negotiated agreements has given rise to numerous disputes among the signatories. Although the Subsidies Code relates to all trade, most of the disputes have occurred in agriculture. This problem is discussed in more detail in Chapter 5.

The Practice of Agricultural Trade

The legal exemptions granted to agriculture in Articles XI and XVI of the General Agreement have contributed to making agriculture one of the most contentious areas of international trade. Agricultural trade seems to have become increasingly separated from the letter and, in particular, the spirit of the General Agreement. When compared with other sectors or industries, agriculture stands out in at least the following respects: on average, tariff protection is higher than in most other sectors (Table 1), with many tariffs still unbound and at levels that discourage trade; tariff escalation is commonplace and serious (Table 2); the number of non-tariff barriers is high compared with the manufacturing average (Table 3); and export subsidies are used on a large scale, distorting trade flows and sparking frequent trade disputes.

³ During the Dillon Round, the United States managed to secure a "zero-duty binding" for oilseeds, oilseed meals, and some other feed substitutes from the EC. Although not considered of major importance at that time, this concession has proven to be one of the most significant ever achieved by the United States.

⁴ The addition of codes to the General Agreement during the Tokyo Round is discussed in Stern and Hoekman 1987, 59-66.

Table 1—Average applied tariffs for 11 developed market economies, by product group, 1983

Product Group	Tariff Application	
	All Imports	Imports from Less-Developed Countries
	(percent)	
Food	5.3	5.5
Agricultural materials	0.5	0.5
Fuels	0.6	0.6
Chemicals	3.1	3.7
Other manufactures	4.7	6.7
All items	3.0	2.7

Source: Based on data from Samuel Laird and J. Michael Finger, "Protection in Developed and Developing Countries: An Overview," paper presented at the World Bank-Thailand Development Research Institute Conference, Bangkok, October 1986 (mimeographed), p. 7.

Table 3 reveals that nontariff barriers are more prevalent in agriculture than in manufacturing for most referenced countries. The extent of nontariff protection in agriculture is similar to that of the most highly protected industries within manufacturing—textiles and clothing as well as iron and steel. Table 4 provides a breakdown of nontariff protection in agriculture by type of measure. Both Tables 3 and 4 omit a number of potentially important trade restrictions. Among those nontariff barriers excluded are domestic policy measures such as subsidies to import-competing sectors, government procurement, and restrictions on the domestic sale of foreign goods; generalized procedures applying to all imports; restrictive business practices;

Table 2—Post-Tokyo Round applied tariffs for raw and processed products of selected developed countries

Product	Austria	EC	Japan	Norway	Switzerland	United States
	(percent)					
Meat						
Fresh and frozen	0.2	6.6	10.1	8.3	4.2	1.6
Processed	2.6	17.9	22.5	8.1	5.2	2.3
Vegetables						
Fresh	2.1	6.7	9.0	3.4	4.9	7.6
Processed	13.3	15.1	17.5	6.6	11.4	11.0
Fruit						
Fresh	3.1	7.7	21.5	1.0	7.4	1.1
Processed	17.3	16.6	21.8	3.1	13.7	20.3
Vegetable oils						
Oilseeds	0.5	0.0	0.3	0.0	0.1	1.0
Oils	1.1	6.1	6.2	4.5	8.2	0.7
Sugar						
Raw	0.0	0.0	3.3	3.6	42.3	0.6
Refined	0.0	0.0	82.5	2.7	34.1	9.9
Tobacco						
Raw	9.7	0.0	0.0	0.0	0.0	8.8
Processed	211.3	61.8	82.1	5.1	17.6	9.1

Source: Based on data from Alexander Yeats, "The Escalation of Trade Barriers," in *The Uruguay Round: A Handbook on the Multilateral Trade Negotiations*, ed. J. Michael Finger and Andrzej Olechowski (Washington, D.C.: World Bank, 1987), p. 114.

Table 3—Percentage of seven industrial countries' imports subject to nontariff barriers, by product group, 1983

Country	Agriculture	Manufacturing	Textiles	Iron and Steel
	(percent)			
Australia	21.6 47.7	28.6 22.7	29.1 28.1	42.5 57.8
Austria	40.5 39.9	6.1 2.4	15.1 0.0	0.0 0.0
EC	26.9 47.7	29.9 15.2	68.0 15.6	31.9 51.8
Japan	53.3 36.8	4.4 9.7	13.0 11.0	0.0 0.0
Norway	15.4 27.0	20.9 3.2	59.5 39.5	20.6 0.0
Switzerland	67.3 74.9	19.5 17.4	45.8 60.8	7.7 3.8
United States	25.1 23.5	18.6 16.5	64.0 31.1	48.9 35.6

Source: Selected data from Julio J. Nogues, Andrzej Olechowski, and L. Alan Winters, *The Extent of Nontariff Barriers to Imports of Industrial Countries*, World Bank Staff Working Papers 789 (Washington, D.C.: World Bank, 1986), p. 52.

Note: Upper numbers refer to imports from developing countries, lower numbers to imports from industrialized countries.

Table 4—Percentage of seven industrial countries' imports of agricultural products subject to nontariff barriers, by type of measure, 1983

Country	Quantitative Restrictions	Decreed Prices ^a	Tariff Type ^b	Monitoring ^c
	(percent)			
Australia	21.4 44.8	0.2 1.7	0.0 0.0	0.0 3.0
Austria	37.8 14.3	3.0 24.6	1.2 9.1	0.0 0.0
EC	14.1 21.3	13.4 27.2	6.6 8.0	2.7 2.2
Japan	46.0 31.4	0.0 0.1	7.9 6.2	0.0 0.0
Norway	14.4 24.9	5.2 5.0	5.6 3.6	0.2 0.5
Switzerland	19.4 47.0	0.2 8.8	0.9 2.6	50.3 26.7
United States	18.1 8.7	15.2 4.1	3.8 2.2	3.3 13.0

Source: Selected data from Julio J. Nogues, Andrzej Olechowski, and L. Alan Winters, *The Extent of Nontariff Barriers to Imports of Industrial Countries*, World Bank Staff Working Papers 789 (Washington, D.C.: World Bank, 1986), p. 55.

Note: Upper numbers refer to imports from developing countries, lower numbers to imports from industrialized countries.

^a Variable levies, minimum import and export prices.

^b Tariff quotas, seasonal tariffs.

^c Price and volume investigations, surveillance, antidumping, and countervailing duties.

and technical or sanitary standards. (More detail is provided in Nogues, Olechowski, and Winters 1986, 7.) Especially the omission of quality standards and state trading is likely to seriously underestimate the extent of nontariff barriers for agriculture. (See Bale and Koester 1983 for an assessment of the importance of nontariff barriers for agriculture.)

Recently, domestic production subsidies have also grown in importance for agricultural trade, threatening to nullify or impair market access in an indirect way, other than through border protection. For example, in early 1988 the United States was about to bring before the GATT a dispute it has had for some time with the EC regarding production subsidies by the EC to soybeans and other oilseeds. The subsidies are considered by the United States to be a violation of Article XXIII of the General Agreement because they have effectively nullified or impaired the zero-tariff binding the United States received from the EC on these products during the Dillon Round.

High tariff and nontariff protection are indicative of a massive diversion of resources in favor of agricultural support programs. Table 5 provides some idea of the order of magnitude of the financial transfer for the larger OECD countries. It should be noted at the outset that not all expenditures listed in the table are equally trade distorting. Deficiency payments, for example, which fall under the category "price and income support," distort trade less than variable levies that give rise to domestic surpluses and their eventual disposal via export subsidies. Subsidies to domestic consumers, a big expenditure item of the U.S. agricultural program and included under the item "processing, marketing, consumer aid," even counteract some of the trade-distorting effect of agricultural support programs.

The figures on taxpayer and consumer expenditures in Table 5 are for the period 1979-81. Although they are lower than the presently incurred costs for most countries, they have the advantage of being roughly comparable across countries. In particular, the EC and Japan clearly stand out in that their consumer expenditures are particularly high relative to taxpayer expenditures. This reflects in part their heavy use of frontier barriers to trade relative to other

Table 5—Financing of agricultural policy by seven industrial countries, - 1979-81 average

Expenditures	Australia	Austria	Canada	EC-Total ^a	Japan	New Zealand	United States
Taxpayer expenditures							
Total (ECU billion)	0.47	0.49	1.64	21.15	10.19	0.25	19.39
Share due to—							
Processing, marketing, and consumer aid (percent)	7.0	1.9	14.9	10.2	1.6	0.1	54.6
Price and income support (percent)	21.7	69.3	51.8	56.8	43.8	33.3	18.3
Research and extension (percent)	46.4	2.9	10.6	6.0	3.3	19.9	4.2
Other ^b (percent)	24.9	25.9	22.7	27.0	51.3	46.7	22.9
Consumer expenditures (ECU billion)	0.2	0.9	0.9	35.8	16.7	0.0	7.0
Total expenditures ^c							
Per capita (ECU)	43	188	103	208	204	79	115
Per worker in agriculture (ECU)	1,558	4,786	4,203	7,465	4,090	1,778	7,453
Per hectare (ECU)	1.3	384.2	35.9	613.4	4,361.5	17.0	61.3
As percent of GDP	0.5	2.6	1.2	2.8	2.9	1.4	1.3

Source: Based on data from Organisation for Economic Co-operation and Development, *National Policies and Agricultural Trade* (Paris: OECD, 1987), pp. 128, 132, 134.

Note: ECU = European Currency Unit.

^a Includes expenditures by the European Community authorities and those of the national governments of member states.

^b Inspection services and disease control, rationalization of production, improvement of structures, rural development, and other expenditures whose breakdown by category of expenditure is not available.

^c Includes taxpayer and consumer-financed expenditures.

countries (Table 3). Heavy reliance on border measures is likely to be more disruptive to international trade than nonfrontier barriers. Yet from the viewpoint of domestic politics, such measures look rather attractive. Not only can border measures be more easily justified in terms of food security, they also make it easier to maintain larger agricultural support programs because their financial burden is borne by generally uninformed and hence docile consumers rather than by possibly not-so-docile taxpayers.⁵

The share borne by consumers via higher prices is far more difficult to ascertain than federal budget allocations to agricultural support programs that are subject to highly public discussions. Hence, viewed from this perspective, higher levels of agricultural support would be expected in countries relying more heavily on consumers than on taxpayers to pay for agricultural support. This seems to be borne out in reality. Austria, the EC, and Japan, the three countries that make their consumers bear the brunt of the financial burden of agricultural programs, also have the highest overall expenditures on agricultural support programs, both per capita and per hectare of cultivated land.

Tables 6 and 7 provide a glance at fiscal expenditures over time for the EC and the United States, respectively. (Note that, unlike Table 5, Table 6 considers only the supranational expenditures of the EC. National expenditures in addition to these are included in Table 5.) Unlike the more comprehensive Table 5, Tables 6 and 7 refer only to expenditures for price and income support. For the EC as a supranational institution, this category comprises about three quarters of all fiscal expenditures on agriculture. By contrast, it is much less important for the United States, although it has increased in significance since the passage of the 1985 farm bill.⁶ Most of the expenditures of the United States are concentrated downstream from farm production. They are used to improve sales of agricultural products through marketing assistance, better processing infrastructure, market research, and, in particular, through consumption subsidies (Table 5).

Tables 6 and 7 not only document the growth in fiscal expenditures on agriculture, both in absolute terms and relative to gross domestic product (GDP), they also give a rough idea of the distribution by commodity of these expenditures. For both the United States and the EC, dairy products and cereals receive most of the support payments. As a result, it is not surprising to find that the world markets for these products are among those that are the most distorted.

Table 8 provides some recent estimates of the degree of world market distortion for some cereal and dairy products and a few others. The figures in the table give just an order of magnitude; differences in methodology and data base can lead to somewhat different results without, however, changing the basic message that many markets for agricultural products are heavily distorted by government intervention.⁷ World market prices and trade flows, rather than comparative advantage, have come to reflect the relative ability of countries to subsidize. Market access has become highly uncertain for exporters, thereby inflicting a heavy burden on nonsubsidizing exporters, including numerous highly indebted developing countries. In addition, market or price stability has been lost as world markets increasingly degenerate into

⁵ See Hayami 1986, 37-38. Note, however, that export subsidies, although classified as frontier barriers, are financed out of tax revenue.

⁶ For the years 1979 through 1981, the average percentage of U.S. fiscal expenditures in this category was only 18.3 percent according to Table 5. With the farm bill of 1985, however, this ratio has increased, as expenditures for income and price support have risen about sevenfold from 1979-81 to 1986-87.

⁷ Numerous quantitative studies have appeared in the 1980s, among them Valdés and Zietz 1980; Organisation for Economic Co-operation and Development 1987; and Tyers and Anderson 1986. A convenient survey of quantitative results is provided in Valdés 1987. A very readable account of the anomalies of international agricultural trade is provided by Miller (1986).

Table 6—Gross expenditures by the EC for price support and income transfers, 1974-87

Type	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Outlays of EAGGF ^b	3.1	4.7	5.6	6.8	8.7	10.4	11.3	11.0	12.4	15.8	18.4	19.7	22.1	23.0
	(EUA/ECU billion) ^a													
As share of EC GDP	0.34	0.46	0.44	0.48	0.55	0.59	0.57	0.49	0.51	0.61	0.66	0.66	0.63	0.62
Share of—														
Restitutions ^c	19.0	20.5	26.2	37.5	40.8	47.7	50.6	46.8	40.8	33.8	34.5	33.8	33.5	39.8
Interventions ^d	81.0	79.5	73.8	62.5	59.2	52.3	49.7	53.2	59.2	66.2	65.5	66.2	66.5	60.2
Share of—														
Dairy products	39.4	24.3	40.8	42.8	46.3	43.4	42.0	30.0	26.8	27.6	29.6	29.9	24.4	26.6
Beef	10.5	20.7	11.0	6.8	7.4	7.2	12.0	12.9	9.3	10.9	13.9	13.8	15.7	10.2
Cereals	12.9	13.1	11.7	9.2	12.8	15.0	14.8	17.2	14.7	15.3	9.0	11.6	15.3	15.9
Sugar	3.5	6.5	4.1	8.8	10.1	9.0	5.1	6.9	10.0	8.3	8.9	9.1	7.8	7.1
Oils and fats ^e	4.6	4.9	5.5	4.5	3.7	5.8	6.1	9.2	9.8	10.2	9.5	9.1	11.8	13.2
Fruit and vegetables	2.2	1.9	3.3	2.6	1.2	4.2	6.1	5.8	7.4	7.5	7.3	6.2	4.4	4.2
Wine	1.4	2.9	2.4	1.3	0.7	0.6	2.6	4.1	4.6	4.1	6.0	4.7	2.8	5.5
Other products	25.7	25.5	21.1	24.0	17.8	14.9	11.3	13.9	17.4	16.1	15.2	15.6	17.8	17.3

Source: Based on data from Commission of the European Communities, *The Agricultural Situation in the Community*, various issues (Brussels and Luxembourg: CEC, various years).

^a From 1974 to 1978, expenditures are given in European Units of Account; from 1979 to 1987, they are in European Currency Units. Figures do not include expenditures by national governments.

^b European Agricultural Guidance and Guarantee Fund; the figures exclude expenditures of the "guidance section."

^c Export subsidies.

^d Including stock holding, less production levies for milk.

^e Includes expenditures for olive oil.

Table 7—Net expenditures by the United States for price support and income transfers, 1974-87

Type	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Total expenditures ^a	1.0	0.6	1.0	3.8	5.6	3.6	2.7	4.0	11.6	18.8	7.2	17.6	25.8	22.4
	(US\$ billion)													
As share of U.S. GDP	0.07	0.04	0.06	0.19	0.25	0.15	0.10	0.13	0.37	0.56	0.19	0.44	0.61	0.50
Share of ^b —	(percent)													
Maize	44.2	26.1	11.0	10.5	30.2	24.3	46.2	38.5	36.9	30.5	...	25.1	40.7	55.1
Wheat	20.8	4.4	6.9	49.8	14.9	8.4	31.9	47.4	19.2	18.2	35.1	26.4	13.3	12.7
Dairy products	4.6	73.8	4.0	12.3	4.3	0.7	37.2	18.8	13.5	13.5	20.9	11.9	9.0	5.2
Cotton	72.2	40.5	0.8	2.7	4.0	4.0	2.4	8.4	10.3	7.3	3.4	8.8	8.3	8.0
Soybeans	2.6	...	...	0.1	0.6	0.1	4.3	2.2	1.5	1.5	...	4.0	6.2	...

Source: Selected data from Joachim Zietz, "Der Agrarsektor in den GATT-Verhandlungen," *Die Weltwirtschaft* 1 (June 1987): 200-211.
 Note: Expenditures on PL480 food aid are excluded.

^a Gross expenditures minus repayments of credit.

^b Shares of the net expenditures do not sum to 100.

^c Receipts exceed expenditures because of repayment of credit.

Table 8—Price and trade effects of agricultural protection, by various products and countries, 1980-82

Effect	Wheat	Feed-grains	Rice	Beef and Veal	Dairy Products	Sugar
	(percent)					
Change in world market price	-9	-3	-10	-21	-38	-10
Change in world trade volume	6	-9	-15	-63	-39	-3
	(million metric tons)					
Absolute change in export volume						
Group 1 ^a	4.5	4.0	3.8	5.6	14.0	2.3
Group 2 ^b	3.0	-8.6	0.2	-2.1	14.4	0.7
Group 3 ^c	-2.6	1.9	-0.0	-0.5	-6.2	-0.0
Group 4 ^d	-4.9	2.3	-4.0	-2.9	-22.0	-2.9

Source: Based on data from Rodney Tyers and Kym Anderson, "Global Interactions and Trade Liberalisation in Agriculture," University of Adelaide, April 1987 (revised mimeo).

^a Western Europe (12 countries in the European Community, 5 in the European Free Trade Association), Japan, Korea, Taiwan.

^b Australia, New Zealand, Canada, United States.

^c Centrally planned economies of Eastern Europe.

^d Other developing countries.

dumping grounds of domestic farm policies that have run out of control.⁸ It is not surprising then that agricultural trade has become the area of many, if not most, trade disputes and conflicts in recent years.

What have been the reasons for the persistence and growth of agricultural protection? This question is not trivial; the costs of protection are large and extend beyond agriculture into other sectors of the economy.⁹ In addition, the agricultural population is rather small in most industrial countries and is continuing to shrink. For example, the average percentage of the labor force employed in agriculture for the 19 countries classified as Industrial Market Economies by the World Bank was only 6 percent in 1981, compared with 14 percent in 1965 (World Bank 1985, 215). Nevertheless, farmers seem to be able to muster considerable political clout.

To a large degree the political influence of farmers simply reflects a rational complacency on the part of consumers. Although consumers potentially gain the most from trade liberalization, there are well-known problems in rallying their support: (1) lack of appropriate information regarding the costs of agricultural protection for food prices, but also for job creation in nonagriculture, results in small perceived personal gains from liberalizing agricultural trade; (2) other things being equal, the costs of agricultural protection per capita decrease with rising incomes because the income elasticity of demand for agricultural goods is generally less than unity; (3) high transaction costs make it difficult to organize a large body of people with diverse interests, such as consumers, as opposed to a smaller and shrinking group with distinct concerns in just one subject; and (4) the income loss that results from agricultural protection may be

⁸ Quantitative evidence on the instability of world agricultural markets as it results from import protection is provided in Schiff 1985. See also Tyers and Anderson 1987.

⁹ The analysis of the costs of agricultural protection to sectors outside of agriculture is rather new. Examples of this type of work were recently presented at a joint conference of the American Enterprise Institute and the Center for International Economics (Australia) on "Agricultural Policies and the Non-farm Economy" in Washington, D.C., May 26-27, 1988. For example, see Stoeckel and Breckling 1988 and Donges et al. 1988.

considered akin to an insurance premium that buys social solidarity if an individual's job should be in danger. (See Hayami 1986 and Honma and Hayami 1986 for more detailed analyses of these problems.)

The aspect of solidarity also goes some way in explaining why protection in agriculture, however costly it may have come to be, meets with little resistance from other sectors and industries. As long as persistent protection in agriculture does not directly affect other industries in the form of reduced subsidies or forgone profits of significant magnitude, little change can be expected in their acceptance of agricultural protection. In sum, an insufficient degree of domestic countervailing power, that is, the lack of a forceful and influential antifarm lobby, is a reason, if not the main one, for the political clout of farmers.¹⁰

Apart from that, the growth of agricultural protection can be traced mainly to two factors: the decline in the relative size of the agricultural sector and trade retaliation. A decrease in the relative size of the agricultural sector allows, all else being equal, for an increase in protection without requiring a change in the level of budget outlays. Retaliation for one country's protective actions may partially or fully eliminate the intended effect of the protection. Hence, in a world where trade retaliation is the rule rather than the exception, securing a certain protective effect to farmers may require, if not an ever-increasing level of protection, then certainly an ever-increasing level of budgetary outlays (Tables 6 and 7).

Even the high degree of protection currently applied in many industrialized countries and their considerable budgetary outlays do not appear to be sufficient to compensate for the effect of similar actions in most industrialized countries. Indeed, retaliatory actions have resulted in making farmers worse off now than they were years ago. Despite escalating costs, recent experience in many industrialized countries has seen declining rather than rising farm incomes (Organisation for Economic Co-operation and Development 1987, 59). In addition, there is no evidence that agricultural policies have managed to reduce income disparities within agriculture, one of the prime reasons for government intervention in the market in the first place. Instead it appears that the large, well-to-do farmers are reaping most of the benefits of governmental programs, thereby making agricultural protection a highly inefficient redistribution scheme (see Koester and Nuppenau 1987). A recent study found, for example, that for both the United States and the EC more than 75 percent of agricultural assistance is received by less than 25 percent of all farmers (Organisation for Economic Co-operation and Development 1987, 59).

Reactions to Mounting Protection

Mounting budgetary costs, disruptive trade disputes, and the realization that the target group of agricultural market intervention is not reached to the intended degree seem to have made industrialized countries more perceptive of the need for agricultural trade reform in recent years. In line with this sharpened awareness, work on a new multilateral trade round started in the Committee on Trade in Agriculture in 1982, when it was established within the GATT framework by a ministerial conference. At about the same time the OECD Secretariat was given the mandate by its Ministerial Council to analyze the effects of agricultural protectionism and ways to improve the functioning of world markets for agricultural products.

Efforts for a new trade round culminated in the Special Session of the GATT Contracting Parties in Punta del Este (Uruguay) in September 1986. On the occasion of this special session the ministers of GATT member countries adopted a declaration launching a new round of

¹⁰ For a discussion of the political-economy problems in the EC, see Schmitt 1986. A more comprehensive study that includes the United States is Petit 1985.

multilateral trade negotiations—the Uruguay Round. The main results of the constituting meeting in Punta del Este, as they relate to agriculture, broadly reflect the concerns expressed in recent research: improving market access, reducing direct and indirect subsidies with trade impact, and minimizing the trade impact of health regulations and standards.¹¹ That an agreement was reached at all in Punta del Este is by itself no small surprise, given the diversity of interests represented at the conference. However, identifying the agenda for action, although a necessary first step for reform, is not equivalent to agreement on the needed course of action. After all, disagreement on the appropriate policy reforms is not limited to policymakers of different countries, but also figures prominently among economic researchers.

Almost two years after the Punta del Este declaration, overall progress is rather modest. Separate negotiating groups have been set up for each of the 14 "Subjects For Negotiation" mentioned in the Punta del Este declaration (see Appendix 3 for a list of these subjects). Of these, four are sector- or commodity-specific—the groups for tropical products, natural resource-based products, agriculture, and textiles and clothing. It may be noted that agricultural products are discussed in three of the four groups. Other negotiating groups are dealing with barriers to trade, such as tariffs, nontariff barriers, and subsidies, and yet others with GATT articles, safeguards, and related matters.

Within the various groups, much of the time has been spent on taking stock of the various proposals that have been put forth by the contracting parties. Depending on the complexity of the issues, progress is rather varied among the groups. The group on tropical products,¹² for example, which is of central importance for many low-income developing countries, seems to have progressed rapidly. (See Valdés and Zietz 1980 for the quantitative importance of the tropical products group for LDCs.) It even seems possible that an initial round of tariff reductions can be put into effect for tropical products by 1989. By comparison, the negotiating group on agriculture, which is of central interest to most industrialized and many higher-income developing countries,¹³ took until the end of 1987 just to collect the reform proposals of the main participants in international trade.¹⁴

Six major reform proposals have been tabled in the negotiating group for agriculture (an overview of these proposals can be found in U.S. General Accounting Office 1988). They come from the United States, the Cairns Group,¹⁵ Canada,¹⁶ the Nordic countries,¹⁷ the EC, and Japan. The proposals can be grouped into two broad categories, one with a comprehensive scope covering all commodities and calling for the removal of all trade-distorting measures, and one

¹¹ The complete text of the Punta del Este Declaration can be found in GATT Secretariat 1986. An abbreviated version of the Ministerial Declaration on the Uruguay Round with citations of those passages of particular interest in the context of this study is presented in Appendix 3.

¹² Seven product groups are part of this negotiating group: tropical beverages (coffee, cocoa, and tea); spices, flowers, and plants; certain oilseeds, vegetable oils, and oilcakes; tobacco, rice, and tropical roots; tropical fruits and nuts; tropical wood and rubber; and jute and hard fibers.

¹³ Higher-income developing countries are mainly affected as exporters. The concerns of many food-importing low-income developing countries, whose terms of trade would deteriorate with restrictions on export subsidies, have been given rather scant attention so far in the negotiating group on agriculture, although Jamaica, supported by a number of other developing countries, has put forth a communication to this effect. See GATT Secretariat 1988b, 6.

¹⁴ The second phase of the negotiating group for agriculture, which began in February 1988, will concentrate on the actual negotiations. It has no fixed completion date.

¹⁵ The Cairns Group was established in Cairns, Australia, in August 1986. Its members are Argentina, Australia, Brazil, Canada, Chile, Colombia, Hungary, Indonesia, Malaysia, New Zealand, the Philippines, Thailand, and Uruguay. The countries of the Cairns Group represent some 550 million people and account for roughly one quarter of the total amount of agricultural exports.

¹⁶ Although a member of the Cairns Group, Canada proposed a more detailed plan of its own.

¹⁷ This group consists of Finland, Iceland, Norway, and Sweden.

with a narrower scope, particularly regarding the removal of import restrictions and domestic subsidies. The proposals of the EC, Japan, and the Nordic countries fall into the latter category, the remaining proposals into the former.

The most sweeping proposal comes from the United States (see the statement of Undersecretary of Agriculture Daniel Amstutz in U.S. Department of Agriculture 1987). It calls for the elimination, gradually over 10 years, of all barriers to agricultural imports and of all farm subsidies that distort agricultural trade either directly or indirectly.¹⁸ In adopting the measurement concept of the OECD Ministerial Mandate study (Organisation for Economic Co-operation and Development 1987), the U.S. proposal suggests converting all support programs to a common denominator, such as the Producer Subsidy Equivalent (PSE), which is discussed in detail in Chapter 5. Exempted from this are programs with little or no effect on production and trade, such as certain forms of food aid and income supplements not linked to production. The proposals by the Cairns Group and Canada are similar to the U.S. proposal in principle. (The idea behind the Cairns Group proposal is discussed in some detail in Reeves 1987.) These proposals also subscribe to some degree or other to the measurement concept of PSE or modifications thereof. In contrast to the U.S. proposal, however, they also contain some suggestions for short-term measures, such as a freeze on import restrictions and all subsidies affecting trade.

The EC position is far removed from that of the United States. In fact, compared with the U.S. proposal it is at the opposite end of the spectrum. Its main focus is short run rather than long run. What the EC proposes, at least in a much-emphasized initial phase, is essentially a system of market management, that is, an item-by-item agreement on minimum prices and market sharing for those commodities for which the world market appears to be particularly distorted—grains, dairy products, and sugar. (Part of the short-run solution appears to be the EC's desire to harmonize protection levels for grains and grain substitutes, which implies raising the protection levels for grain substitutes to those for grains.) In a second phase, the EC envisions some longer-term concerted reduction, though not elimination, of farm support programs. However, the EC has not made it clear how the second phase is linked to the first. Despite the general vagueness of the EC proposal, it seems clear that the EC is not willing to discuss the basic structure of the Common Agricultural Policy.

The trade reform proposals of Japan and the Nordic countries have in common with the EC proposal that they do not call for the complete elimination of all import restrictions and domestic subsidies, but only for their reduction. Both are disposed toward severe restrictions on export subsidies because that is where they appear to see the main root of the current problems in agricultural trade—a position that essentially reflects their status as net importers of agricultural products. The Nordic countries support the aggregate negotiating approach, favored also by the United States, for reducing levels of support based on PSE or similar measures. Japan, in contrast, has rejected the PSE approach to the negotiations on the grounds that it could not reflect the special characteristics of a country's agriculture.

Given the disagreement over agricultural trade reform between the United States and the EC, the two main players in the negotiations, the initial optimism after the signing of the Punta del Este declaration seems to have given way to pessimism and frustration.¹⁹ Apart from the EC and Japan, most participants appear to favor at this time a closer look at the usefulness of the PSE measurement concept, which was at the center of the OECD Ministerial Mandate

¹⁸ In addition, the United States proposes harmonizing health and sanitation regulations among GATT signatories so that differences cannot be used as indirect trade barriers. This idea is not controversial among the participants of the Uruguay Round. Essentially all countries have a similar element in their own proposals.

¹⁹ See, for example, *Agra Europe*, March 18, 1988, E/1-E/2.

study. The hope behind this seems to be that by establishing a general approach to the negotiations in agriculture, the current deadlock can be overcome.

This idea may of course be generalized for the whole Uruguay Round. What appears to be missing at this point is a simple central theme or unifying principle, similar to the across-the-board tariff-cut idea of the last two multilateral trade negotiation rounds. It may be asked to what extent concepts such as PSE that appear attractive for agricultural products, but only agricultural products, will not enhance but inhibit progress for the Uruguay Round as a whole by preventing agreement on a truly general reform concept that is applicable across all products. It seems that not only the negotiating group on agriculture is in need of a unifying concept or a clearer set of guideposts by which to organize its discussions. Other negotiating groups appear to face a similar problem.

The following two chapters undertake to facilitate the process of finding such a unifying principle for the Uruguay Round by clarifying some of the more important issues surrounding various proposals for trade reform in agriculture, providing some needed structure to the debate on diverse proposals, and discussing the likely economic consequences and political-economy implications of some ideas for reforming agricultural trade within the GATT.

4

CRITERIA FOR EVALUATING TRADE REFORM PROPOSALS

Conformity With GATT Principles

The GATT is built around a number of fundamental principles that form the backbone of the current trading system. Nondiscrimination by country of origin and a general ban on quantitative import restrictions are the two most important of these principles. During a time when trade disputes seem to be a regular occurrence, the disciplines that these principles are supposed to impose on the trading system and its participants appear to be eroding (see Teese 1982). GATT rules based on these principles are simply being ignored—for example, the provisions of the safeguard clause of Article XIX—or they are being circumvented by resort to gray-area measures such as voluntary export restraints.

In the light of this erosion process, at least one school of thought, popular in the EC, draws the conclusion that the growing disregard of GATT rules can be stopped only by rewriting them in a way that relaxes their reliance on pristine principles such as nondiscrimination. The idea is to bridge the apparent gap between reality and the rules of behavior mandated by the General Agreement by adjusting the rules so they better reflect reality (see the discussion in Adlung 1987). In practical terms this means, for example, eliminating the nondiscrimination or compensation provisions from the safeguard clause of Article XIX. This would increase, it is argued, the incentive to stick to Article XIX, or its watered-down revision, rather than to opt for mechanisms outside of GATT, such as voluntary export restraints. Experience with vague GATT rules in agriculture, however, does not give much credibility to this view. On the contrary, the experience of agriculture amply demonstrates that vaguer, less-demanding formulations of GATT rules that chip away at the fundamental principles of the General Agreement are more likely to provoke serious trade disputes or even trade wars than to bring about more GATT discipline. Hence there is evidence to suggest that weakening the rules of behavior mandated by the General Agreement and its underlying principles is a serious mistake.

A better alternative may be to try to reinforce the GATT and its basic principles through improved operational rules and regulations. Improvement in this sense does not mean compromising the principles of the General Agreement through weakened rules of behavior but rather making the rules that incorporate these principles more compatible with the incentives governments face. The principles themselves are too important to be given up. Their significance for a proper functioning of the GATT system is discussed in the remainder of this section.

Nondiscrimination

The cornerstone of the GATT trading rules is the principle of nondiscrimination, also known as the principle of "unconditional, most-favored-nation" (MFN) treatment. It requires that any trade advantage granted to one signatory of GATT be extended to all others. Likewise, import restrictions apply equally to imports from all sources. The MFN principle ensures equal trading opportunities for all signatory countries and provides a multilateral as opposed to a bilateral framework for the international trading system.

The importance of the MFN principle for the international trading system can hardly be overestimated. It is by far the simplest and, if enforced properly, probably one of the most

effective ways of moderating the growth of protectionism. Indeed, the spread of protectionism can be traced largely to the growing disrespect for the MFN principle.²⁰ Voluntary export restraints or selective import restrictions are examples of blatant violations of the MFN principle. A single country or a few of the most efficient and hence lowest-cost exporting countries are singled out under these schemes and subjected to trade restrictions.

Strict adherence to the MFN principle would mean imposing import restrictions on all trading partners in an equal manner, with two important consequences. First, it would mean treating the most efficient and hence lowest-cost producer in the same way as less efficient producers, thereby improving the efficiency of international resource allocation. Second, the level and duration of import protection would probably be reduced. As all actual and potential suppliers would be affected by import restrictions, more political pressure would be put on the import-restricting country than is applied in a system dominated by bilateral trade agreements.

Stepped-up pressure would most likely result from three sources. First, the largest trading nations with the most political power would be subjected to the same restrictions as smaller and politically less influential countries. This would raise significantly the price to be paid by protecting countries for additional import protection. A particular special interest group, such as grain farmers or the farm lobby in general, would have a harder time convincing politicians of the merit of protectionist measures in their area of interest when retaliation by a potent trading partner was threatening to damage the trade interests of other special interest groups in the country, such as meat producers or machine tool manufacturers. Second, global restrictions would eliminate the quota rents that many exporters now receive as partial compensation for their export restraint. As these rents can be substantial,²¹ their removal would make exporters much less likely to quietly accept restraint agreements. Third, nondiscriminatory protection is making it easier for consumers and voters to identify the true economic costs of protection. Better knowledge may provide an additional impetus to the eventual removal of import protection. (See Banks and Tumlin 1986 for a discussion of this and other advantages of the MFN principle for international trade.)

Since the MFN principle has great potential for restraining protectionism, it is worth every effort to strengthen it. This would include, among other things, avoiding the introduction of new rules that are either not in full agreement with the MFN principle or are silent on it, thereby allowing signatory countries to easily avoid its disciplines. Chapter 5 includes a discussion of the possibility that rewriting the GATT rules for agriculture around the concept of PSEs could weaken the force of the MFN principle.

The history of the General Agreement demonstrates that full and unconditional enforcement of the MFN principle is not easy to achieve. It may conflict with such matters as customary procedures in international trade, the interests of powerful lobbies, and conceptions of fairness. For example, a common argument against an unconditional application of the MFN principle in agriculture is the potential terms-of-trade loss for LDCs with preferential access, under the Lomé agreement, to the market of the EC. (The Lomé Convention provides 44 African, 13 Caribbean, and 8 Pacific countries with preferential access to the EC market.) However, this argument against the MFN principle is based on weak foundations, for several reasons. First, any move toward trade liberalization is likely to increase world price compared with what

²⁰ The MFN principle has never had much force behind it in the GATT system, particularly not in the parts of the General Agreement that sanction trade restrictions in specified circumstances, such as Article XIX.

²¹ For example, Hong Kong's quota rents derived from textiles and clothing amount to approximately 2 percent of gross national product. See Hamilton 1986.

it would otherwise be.²² This alone would provide exporting LDCs with some degree of compensation for the loss of preferential access.

Second, there is some evidence that preferential access may actually distort the domestic allocation of resources in LDCs (Dick, Gerken, and Vincent 1982). Economic growth is guided by artificial price signals that may have little relationship to world market conditions in the absence of protection. Preferences then lead to artificial, possibly unsustainable, economic structures in LDCs, requiring restructuring measures that are costly both in economic and political-economy terms once protection in importing countries is dismantled. Unconditional MFN treatment would eliminate this distortion and hence might raise potential real income.

Third, the EC could compensate LDCs directly via income transfers for any remaining income loss. It is unlikely that the required budgetary costs of such a transfer program would exceed the additional market support expenditures currently needed to maintain the preferential access schemes in the face of mounting domestic surpluses. For example, the benefits of the Lomé Convention to the African, Caribbean, and Pacific (ACP) countries that receive preferential access to the EC are not considered to be significant on average. This does not mean that there are not some countries that do capture substantial benefits in certain products (see Koester and Herrmann 1987).

Direct compensation is likely to be possible also in lieu of the Generalized System of Preferences (GSP),²³ especially if the newly industrialized countries are eliminated from the list of countries receiving tariff preferences. As they now reap most of the benefits of the GSP,²⁴ their graduation would cut any potential compensation payments to a minimum. The GSP scheme seems dispensable also on other grounds. It includes only tariffs, not quotas. Unlike the EC-ACP convention of Lomé, the GSP gives LDCs little certainty about the preferences. Since the GSP is not part of a binding commitment under the GATT, but is a completely voluntary concession, it may be revoked at the discretion of the preference-giving country at any time. Clearly, this introduces a great deal of uncertainty and is therefore not conducive to long-run investment decisions in preference-receiving countries.

Finally, preferential-access schemes, regardless of the type, have a definite drawback from a political-economy viewpoint. They tend to promote an alliance of preference-giving and preference-receiving countries against MFN reductions in protectionism. Such reductions are likely to hurt the short-run interests of both import-competing sectors in the protecting country and exporters with preferential access to these protected markets. Both groups are likely to be well organized in their respective countries relative to consumers and other groups that are affected negatively, but less directly, by a system of protection cum preferences. Therefore, governments in protecting countries face little countervailing pressure for a removal of protection, either from within the country or from exporting countries. Preference schemes can thus be a formidable obstacle on the way to an elimination of trade barriers in a multilateral setting.

Although complete and unconditional implementation of the MFN principle will not be easy to achieve, its further erosion has to be avoided because the costs of scrapping the MFN idea are high, both for industrialized and developing countries. The trade regime covering textiles and clothing (known as the Multifiber Arrangement) provides an example of the costs to the international trading system if basic GATT principles such as nondiscrimination are given up.²⁵

²² The many studies on the effects of trade liberalization in agricultural products all point in this direction. See Leddy and Reinstein 1987, Organisation for Economic Co-operation and Development 1987, Hudec 1987, Finger and Olechowski 1987, and Valdés 1987.

²³ Opinions vary widely on this. See, for example, GATT Secretariat 1985.

²⁴ Details are given in, for example, Langhammer and Sapir 1987.

²⁵ Donges et al. (1981) provide a summary account of the issues surrounding the trade regime in textiles and clothing. Spinanger and Zietz (1986) give a shorter description with some illustrative figures.

Put into effect in 1974, prolonged and extended in coverage as well as severity four times since then, the Multifiber Arrangement is the prime example of a sectoral, discriminatory system founded on the principle of managed trade. (A comprehensive discussion of the Multifiber Arrangement and its economic costs can be found in Wolf et al. 1984.)

Managed trade of the Multifiber Arrangement type is synonymous with a tangle of bilateral contracts, with industrialized countries setting their terms. Essentially all efficient, low-cost, developing-country exporters are forced into "voluntary" export restraint agreements, thus leading to the virtual cartelization of the textiles and clothing trade and leaving little if any room for the forces of competition. Also lost on the way is the simplicity of trading in a world of bound tariffs known in advance with certainty to all traders, established and potential. Managed trade under the Multifiber Arrangement has brought relative security of access for a few established exporters, but at the expense of a maze of bureaucratic trade rules and regulations that even experts find ever harder to understand and keep track of. In a word, experience has shown managed trade to be far removed from the letter and spirit of the General Agreement. Its high economic costs make the alternative, that is, the MFN principle, look like a very good deal economically.

Reliance on the Price Mechanism

A second important principle of the GATT is its reliance on the price mechanism as opposed to quantitative rules characteristic of managed trade. This principle is expressed in the use of bound tariffs as the GATT's main form of protection, whereas quantitative barriers to trade are limited to exceptional cases (see Article XI and the corresponding explanatory notes in Appendix 1). The rationale behind this principle is straightforward. Leaving aside for the moment the possibility of prohibitive tariffs, it helps to keep international trade market-oriented in the sense that national economic policies and the resulting trade flows are not allowed to become totally delinked from market forces. Reliance on bound tariffs ensures that the price mechanism is not suspended but merely modified, with all its well-known consequences such as transparency of import protection, predictability of market access, nondiscrimination among suppliers, sourcing from the most competitive supplier, and improved international market stability.

Although most of these results favor all exporters, they are particularly important for developing countries that may have neither the resources nor the expertise to find their way through a thicket of continually changing regulations characteristic of systems of managed trade. Last but not least, bound tariffs as the principal form of protection provide a good basis for further liberalizing trade. Negotiations on tariff reductions are vastly less complicated than negotiations involving quantitative import restrictions like those characteristic of managed trade.

It should be stressed at this point that it is their binding that makes tariffs consistent with the spirit of the General Agreement. Only tariff binding guarantees that the price mechanism is allowed to operate. Notice in this context that variable levies are also tariffs. Yet the fact that they are not bound, but vary along with the world price, makes them equivalent in their effect to quantitative restrictions. They do not allow the price mechanism to operate. On the contrary, they completely insulate the domestic market.

Tariff binding has an important aspect apart from ensuring that the price mechanism is allowed to function. It operates as a natural shield for governments against demands by special interest groups for higher levels of protection. This is because bound tariffs cannot be raised without cost. Once a tariff concession has been made, that is, once a tariff is bound, it cannot be rescinded without extending compensation to the affected trading partners. In the absence of compensation a country faces retaliation (see GATT Articles XIX and XXVIII in Appendix 1).

Compensation is also mandatory when measures are adopted that nullify or impair the value of the tariff binding to the trading partners (Article XXIII). An example of such a measure would

be the tax on soybean and soybean products contemplated by the EC in the early 1980s to circumvent the zero-tariff binding on these products that was granted to the United States at the end of the Dillon Round in return for its acceptance of the Common Agricultural Policy. This tax on vegetable fats would have nullified the tariff binding and hence mandated compensation payments to the United States. Because of the clear stand on this by the United States and its threat of massive retaliation in the absence of adequate compensation, the EC dropped the idea of a vegetable oil tax.

Concentration on Direct Trade Effects

Another element of the GATT is its emphasis on the reduction of government market interventions with a direct, as opposed to an indirect, trade effect. Those with a direct effect, also known as frontier barriers, consist of trade-inhibiting measures that are commonly applied at the border—such as import and export taxes, quotas, and export subsidies—and discriminate between domestic and foreign sources of supplies or between domestic and foreign destinations. (For a thorough discussion of the distinction between frontier and nonfrontier measures, see Snape 1987, 216.) The treatment of products or factors of production depends on their nationality. Measures with indirect trade effects, that is, nonfrontier policies, are made up of taxes and subsidies on production, consumption, or factors of production. They do not generally discriminate between foreign and domestic sources or destinations. For example, a production subsidy is not conditional on the destination of the product. Also, unlike an export subsidy, a production subsidy does not discourage domestic consumption. Similarly, consumption or factor taxes or subsidies do not qualify as frontier barriers as long as they are administered without regard to nationality. (See Snape 1987 for a more comprehensive discussion as well as various qualifications.)

Free international trade as envisioned by the GATT is commonly understood to mean the absence of frontier measures. Most GATT rules and regulations address the containment and reduction of tariff and nontariff barriers to trade as well as of export subsidies and taxes, whereas only a few rules relate to nonfrontier measures, either directly or indirectly. Examples of those related to nonfrontier measures are the rules pertaining to countervailing duties and subsidies as laid down in Articles VI and XVI:1, respectively, and in the Subsidies Code. Domestic subsidies are taken up in an indirect way in Article XXIII in the context of nullification and impairment of tariff concessions.

The historical emphasis on frontier barriers derives from three considerations. First, they generally tend to be visible and therefore more tractable than nonfrontier barriers. This also makes them easier to negotiate.

Second, nonfrontier barriers are more difficult to maintain in the absence of frontier barriers because of their high budgetary costs to governments. (A detailed account of this argument is given in Snape 1987.) Indeed, the complete removal of frontier barriers would probably suffice to keep domestic subsidies in check. The high budgetary cost of domestic subsidies in the absence of border measures contrasts with the budget outlays for frontier barriers. If export subsidies are exempted, frontier barriers can not only be administered cheaply, they can even earn revenue for governments. (This is one of the reasons that border taxes, on either exports or imports, are so popular with developing countries.) They also have certain advantages over domestic subsidies from a political-economy point of view. Border measures invoke less political resistance—because their consequences are difficult to assess in quantitative terms—if they come, as is commonly the case now, in the form of nontariff barriers and their economic costs are spread widely in the economy. Subsidies, in contrast, attract more political attention—because taxes have to go up or other programs have to be cut—thereby provoking conflict with other vested interests. Since even voluntary export restraints or orderly marketing

arrangements that generally worsen the terms of trade for the importer are often preferred over domestic subsidies, the strong preference of countries for border measures is clear.

Third, from a theoretical point of view, domestic subsidies have long been considered a superior means of providing assistance to domestic industry when contrasted to frontier barriers. (See Blackhurst 1981 and the references therein for a discussion of this point.) The standard arguments for domestic subsidies as opposed to frontier barriers are that they can be better targeted; they do not distort consumer prices and hence reduce imports by less than equivalent frontier barriers;²⁶ they are subject to annual budgetary review and hence are much more visible than protection at the border; they are more equitable, assuming the tax system itself is considered equitable; and they provide a convenient way to correct certain market imperfections or failures.

Even if one discounts for the latter arguments, the strong revealed preference of governments for frontier measures and the GATT's traditional focus on this area seem to provide enough reason to question the wisdom of devoting much attention to nonfrontier barriers in the Uruguay Round. What makes domestic subsidies less of an urgent problem is their concentration in just two areas: high technology products (the classic example is the subsidization of the Airbus project by several European countries) and agriculture.²⁷ But even in agriculture, the subsidy issue plays a role mainly in trade disputes between the EC and the United States.²⁸ In addition, it appears that essentially all subsidy disputes in agriculture between the United States and the EC result from sharply different protection levels among products in the EC's Common Agricultural Policy. For example, recent EC subsidies on oilseeds are clearly intended to nullify the zero-tariff binding on soybeans, soybean meals, and certain other feedgrain substitutes that considerably raises EC budget expenditures. It may be hypothesized that the domestic subsidy issue would largely disappear with uniform levels of protection within major groups of agricultural products.

Hence, even though domestic subsidies currently seem to be the cause for considerable friction in trade relations in agriculture as well as certain other areas of trade,²⁹ this may not warrant spending much time and effort in the Uruguay Round on finding a possibly illusive general solution to the subsidy problem, either within the General Agreement or the Subsidies Code. It may be preferable to negotiate subsidies between the affected parties when and where they arise and otherwise concentrate on border measures in the Uruguay Round (see Finger 1987, chap. 20).

Ease of Measurement and Enforcement

Trade reform proposals have little practical merit and are unlikely to improve the international trading regime unless the rules and regulations to enforce them can be defined or measured adequately and are fairly straightforward to monitor. Difficult problems arise with

²⁶ "Equivalent" is used in the sense of granting domestic production activities an equal amount in income transfer. There are cases, however, where frontier barriers are less trade-distorting than equivalent domestic subsidies. For more detail on this subject, see Snape 1987, 222-224.

²⁷ Otherwise, the claim that foreign exporters are unduly subsidized appears to be used mainly by declining industries to gain border protection through countervailing duties. Several pertinent provisions of the Omnibus Trade and Competitiveness Bill of 1987, as drawn up by the U.S. Congress, seem to fall into this category. See the assessment provided in *Economic Report of the President, 1988*.

²⁸ There are exceptions, of course. One notable case involves the U.S. production subsidies to southern rice growers and their negative effect on the international competitiveness of rice grown in Thailand.

²⁹ See, for example, Blackhurst 1981.

rules that leave too much room for avoidance strategies or break down as productivity or demand, or both, change over time. In the following section, these issues will be discussed in somewhat more detail.

Definitions, Measurement, and Monitoring

Reform proposals that rely for their working on exact definitions of highly controversial subjects are difficult to negotiate and to enforce once they are agreed upon. Examples of such difficult-to-define subjects are subsidies with an appreciable effect on trade flows and the equitable market share rule that conditions the use of export subsidies for primary goods. Owing to its generality, this rule has neither managed to effectively restrain countries from using export subsidies nor been of much use for dispute settlement.³⁰ On the whole, it is safe to say that domestic or nonfrontier policies are more difficult to define in multilateral trade negotiations than are frontier measures. The reason is that domestic policies and conventions can be quite different among countries because of historical, cultural, political, or other circumstances. In contrast, external trade is governed by rather similar rules in most countries.

Measurement and monitoring can be a problem whenever large amounts of detailed data are needed, when the required data become available only with a considerable time delay, or when there is no formal procedure established to collect the data. The measurement of domestic subsidies with a trade effect could be such a problem case. At times, the amounts actually spent are difficult or impossible to extract from official sources, given the numerous ways of hiding them. Also, the actual outlays in a budget year, as opposed to planned expenditures, often become available only after some time. Such problems usually do not arise with price data, which may be required by certain trade reform proposals. However, when prices are used for the purpose of price comparisons, other well-known problems arise. Examples are quality differences, either at a particular point in time or over time, and exchange-rate changes.

Quantity-based rules such as quotas are, in general, more easily measured and monitored—the stricter the definition, the easier the task. Whereas "equitable export market shares" can, for all practical purposes, be neither measured nor monitored, import or export quotas defined in tons per time period can be rather easily checked. Hence, for the purpose of striking "deals" among GATT members during multilateral trade negotiations, such quotas seem ideal. This may be one reason that quota-type arrangements appear to be favored sometimes by practical-minded negotiators.

Avoidance Possibilities

Ideally, the rules governing international trade should be structured so that avoiding them by applying gray-area measures (trade instruments not subject to formal GATT disciplines) will be impossible or at least very costly, both economically and politically. This is to say that there should be few loopholes, since special interest groups, in looking for ways to increase protection for their products, can always be counted on to find them. Faced with intense lobbying

³⁰ For example, the first case based on the dispute-settlement mechanism of the Subsidies Code involved EC export subsidies for wheat flour. Although the GATT panel established that the EC increased its market share substantially by its use of export subsidies, the panel was unable, due to the Subsidies Code's imprecise language, to characterize the EC's enlarged market share as inequitable. In other cases, for example those involving subsidized EC pasta exports to the United States and the preferential treatment of Mediterranean citrus imports by the EC, the United States managed to obtain favorable panel decisions, yet the EC either blocked the decisions or chose to simply ignore the panel's recommendation. See Paarlberg 1987, 52-53.

from such groups, however, governments rarely manage to evade the pressure to take advantage of these loopholes. Clearly, loopholes in the system of international trade obligations deprive governments of a protective shield against the political pressure of special interest groups.

Typical examples of loopholes related to frontier measures in the current GATT system are voluntary export restraints, variable levies, the activities of state trading enterprises, and the right to employ export subsidies and import quotas for agricultural products.

There are at least three ways to reduce the use of such loopholes. As mentioned earlier, the stringency of certain rules of behavior could simply be reduced, thus adjusting them toward actual behavior. This could be done for all trade or it could be limited to particular sectors. An example of the latter route is the establishment of the Multifiber Arrangement for clothing and textiles, whose negative consequences have already been outlined. The special exemptions for agricultural trade in the area of export subsidies and import quotas also fall into this category. When the General Agreement was drawn up in the 1940s, these special exemptions had the effect of adjusting the GATT rules for agriculture toward the reality of agricultural trade as it prevailed at that time. The discussion in Chapter 3 gives a short overview of the results in agriculture of adjusting rules of behavior toward actual trade practice.

Alternatively, a system based on bound tariffs could be changed over to one based on summary measures of protection, such as nominal rates of protection (NRP). This way, bound tariffs, for example, could not be circumvented by dubious state trading practices, voluntary export restraints, quotas, or similar frontier barriers. In addition, to cut the option to substitute domestic subsidies for frontier barriers, the NRP measure could be extended to cover domestic subsidies. This would lead to the fixing of overall levels of support, an idea that has recently received considerable attention in agriculture (see, for example, Organisation for Economic Cooperation and Development 1987). Although it is possible with these measures to further reduce avoidance behavior,³¹ they also have certain disadvantages. One of the drawbacks of these types of overall measures is their limited applicability outside of agriculture. Limiting their use to agriculture, however, would mean establishing another special sectoral trade regime. But sectoral trade regimes are problematic from a political-economy point of view, an issue that will be taken up shortly. Also, the experience with the sectoral trade regime for textiles and clothing has not been encouraging.

A third way of dealing with loopholes in the GATT system would be to tighten existing GATT rules, such as those pertaining to state trading, export subsidies, and import quotas in agriculture; to improve the dispute settlement procedures of the General Agreement; and to introduce a limited number of new mechanisms to deal with gray-area measures such as voluntary export restraints. The idea would be to make avoidance behavior more difficult, yet stay with the General Agreement in its present form, without creating new special cases for particular sectors or industries. In Chapter 6 this third alternative is taken up in more detail as part of a comprehensive reform package that is applicable not only to trade in agricultural products but to trade in general.

Resilience to Long-Term Demand and Supply Trends

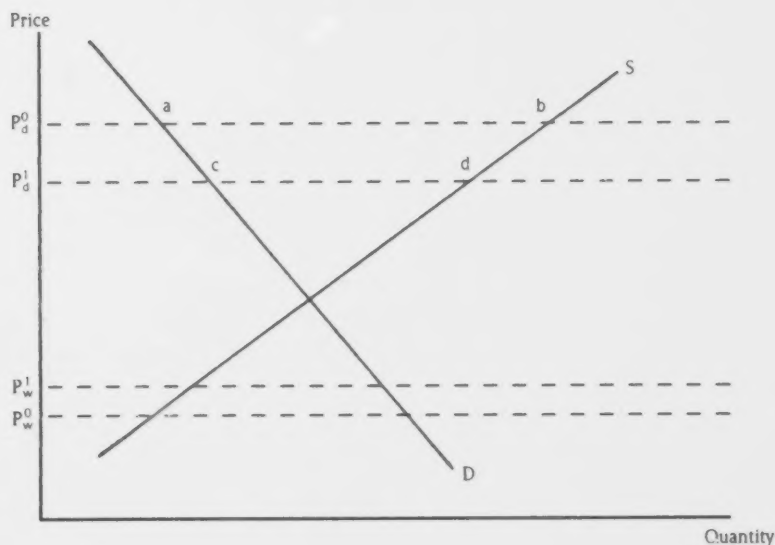
Another question to be addressed in assessing trade reform proposals is how sustainable they are in the face of productivity improvements, possibly combined with slow growth in demand. To put it differently, will the suggested reform proposals make much of a difference given the natural evolution of all other factors that determine quantities and prices? To answer

³¹ As discussed in more detail in Chapter 5, comprehensive measures such as bound producer subsidy equivalents cannot totally eliminate avoidance activities that reduce imports.

this question, an analysis has to distinguish between a reform proposal's *ceteris paribus* effects³² on prices, quantities, and trade and its predicted actual effect. The first type of analysis would compare the state of the world in n years for situations both with and without the policy change. The second type would compare the policy's effects in n years, assuming all other factors were also at work during that time, with the current state of the world. The difference between these two views can be illustrated with the help of a simple graphic example (Figures 1 and 2).

Assume the reform proposal calls for a reduction of the NRP, as measured by $(P_d^0 - P_w^0)/P_w^0$ in Figure 1, of x percent over a period of n years. A typical analysis based on *ceteris paribus* principles would predict a reduction of excess supply in the import-protecting country from ab to cd . The resulting fall in subsidized exports causes the world price to increase from P_w^0 to P_w^1 . Clearly, the nature of this exercise is such that it predicts what would happen if all other factors were held constant. No prediction is made for the actually occurring quantities or prices in n years. This is because the dynamic aspects shaping the actual long-run outcome, that is, the effects of changes in productivity and income, cancel out in this type of analysis. Hence, the prediction of a rise in P_w in Figure 1 implies only that the world price would be higher than without the trade reform, not that it will actually rise in the wake of trade reform, given that all other factors are also changing. This important point is illustrated in Figure 2. It is based on the assumption that, over a longer period, productivity rises by an amount sufficient to shift the domestic supply curve from S_0 to S_1 . During the same time period, income increases so as to move domestic demand from D_0 to D_1 . The shifts in demand and supply curves effect an increase in net exports³³ despite a reduction in nominal protection (the new

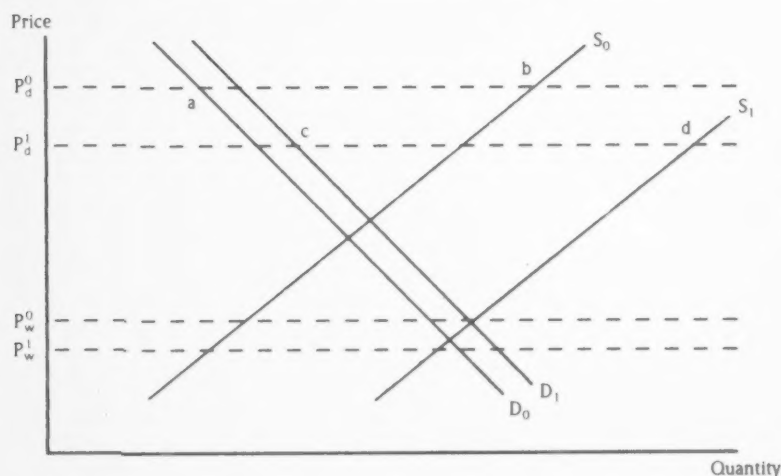
Figure 1—Predicted impact of trade reform on trade volume in n years, with everything else assumed constant



³² The effects above and beyond the predicted changes resulting from innovations in all other determining factors of prices and quantities.

³³ Distance cd exceeds distance ab in Figure 2.

Figure 2—Predicted change in observable trade volume over n years, with trade reform as well as demand and supply growth



level of nominal protection is measured with reference to P_w). Assuming the development in other import-protecting countries is similar and productivity also increases in nonsubsidizing countries, the observed world price is going to decrease rather than increase compared with today's price. Naturally, the world price would show a larger decline in the absence of trade reform.

For the negotiations on trade reform, the predictions for actually observed changes, such as those in world price and market shares that emanate from an analysis along the lines of Figure 2, probably have an information content at least as important as *ceteris paribus*-type predictions, such as those associated with Figure 1. Besides, past experience with multilateral trade negotiations has shown that considerations relating to such factors as productivity have, at least implicitly, featured prominently in the negotiations. Otherwise, trade reform proposals such as freezing market shares or self-sufficiency levels could not be explained. The sole merit of these types of proposals lies in their ability to counteract possibly detrimental effects on export markets of either discretionary increases in protection or, more important, dynamic changes in demand and productivity in import-protecting countries. They are largely devoid of implications that can be captured with an analysis along the lines of Figure 1. A proper analysis of these reform proposals requires a framework like that of Figure 2.

Political-Economy Considerations

There are two levels at which political-economy considerations play an important role for the multilateral trade negotiations within the GATT: the level at which country representatives negotiate with each other, and the level at which domestic interest groups interact with each other and with the government in a given country. As the following discussion will show, these two levels are very much related. Also, the idea of fairness or evenhanded treatment plays a significant role at both levels.

Proposals for trade reform are likely to be uniformly acceptable among negotiating parties only if all signatories to the GATT are treated in an evenhanded manner. However, this can-

not be taken to mean evenhandedness in every sector or even in every commodity group, especially if evenhandedness is defined as a balancing of requests and offers of trade concessions. If this is not clearly understood, the Uruguay Round may not succeed. This point becomes apparent in a consideration of, for example, the new active role in this trade round of developing countries such as the Group of 48 or the Cairns Group on agriculture. The vast majority of their requests for concessions are concentrated in two areas: agriculture and light industries such as textiles and clothing. Nearly all of their potential offers of concessions, however, are in other areas, the major examples being graduation of industrial goods, intellectual property rights, services, trade-related investment measures, and the Generalized System of Preferences. Hence, the balancing of offers and requests of trade concessions would seem to require a look beyond agriculture.³⁴ To put it more directly, developing countries could use concessions in property rights, services, and similar areas to force concessions from industrialized countries in, for example, agriculture and textiles.

Evenhanded treatment of countries implies another important point: aligning trade in agricultural products more closely with trade in manufactures. This involves, among other things, the elimination of special rules and waivers, such as the legality of export subsidies in agriculture as opposed to industry. Failure to do this may make it impossible to garner the support of countries that export mainly agricultural products, such as those countries loosely aligned in the Cairns Group. It would be hard to convince them of the merits of a partial trade reform that improves the trading environment only of countries that happen to export mainly industrial goods. (Clearly, the same argument applies for integration of the textiles and clothing complex into the GATT.)

If the latter point is accepted, then reform proposals specific to agriculture should be avoided. Otherwise the sector will again become subject to rules that are different from those for other trade, thereby treating agricultural exporters differently—most likely less favorably—than exporters of industrial goods. This is both unfair and inherently inconsistent with the GATT's underlying principle of nondiscrimination. In fact, it is just this type of differentiated treatment that has made the whole GATT system increasingly less credible.

The issue of evenhandedness of trade reform is also crucial in any effort to secure the support of special interest groups within a given country for trade reform and thereby to solve the problem of its domestic acceptability in the major trading countries. Domestic acceptability becomes a particularly tricky subject if it is simply measured by the amount of satisfaction or dissatisfaction within the farm lobby. Clearly, any trade reform package emanating from the Uruguay Round should be structured to avoid this. The following considerations would thus seem to be of vital importance.

First, most governments would probably favor the imposition of binding restrictions on protectionist measures (to roll back the influence of special interest groups) in agriculture as much as in other areas. As mentioned earlier, binding international restrictions serve as a kind of protective shield against the demands of special interest groups. If this view is correct, it would make a strong case for trade reform proposals that reduce the discretion of governments over changes in frontier barriers, such as variations of tariff rates, export subsidies, or restrictive state trading practices. As the farm lobby is known to be very powerful in many countries, with a strong representation in most agricultural ministries, too much decision leeway on the part of governments can keep them captives of internal politicking and hence impart a protectionist bias to their trade policy. Tighter restrictions on frontier barriers, through such means

³⁴ Support for this view can be found in Winters 1987. The opposite view is represented by McCalla (1987), who refers in this context to the unsuccessful attempts at negotiating compromises across sectors in previous multilateral trade negotiation rounds.

as mandatory binding of all tariffs and the closing of loopholes for protectionist activity, could make it possible, in principle, to move away from the present unfortunate situation in negotiations between the farm lobby and the government on changes in support or target prices. These negotiations increasingly resemble those for higher wages and benefits between the government and the unions representing its employees.

Second, domestic acceptability of a reform package is a function of the relative political influence of those groups of society that will gain from it and those that stand to lose, in the sense that they are subjected to adjustment costs. (Even groups that have to adjust are likely to gain, since, in the long run, adjustment costs fall solely on factors in fixed supply, mainly land.) As already discussed, consumers would gain the most from a trade reform directed toward more liberalization. But for reasons stated earlier, they are unlikely to form a strong lobbying group. Hence, in terms of making trade reform acceptable to a country, the size of consumers' potential welfare gains means little in getting a trade reform past the legislature. To counter the dominant influence of the farm lobby in countries such as the United States, the EC, and Japan, strong support in favor of trade reform has to come forth from groups that also stand to gain from trade liberalization in agriculture, yet are better organized and more vocal than consumers and hence have sufficient economic and political clout (see Duchêne, Szczepanik, and Legg 1985, 192). Recent quantitative evidence strongly suggests that industry and labor unions are such groups.³⁵ Both industry and labor outside of agriculture could expect to gain considerably from trade liberalization in agriculture. Estimates show, for example, that in the absence of the Common Agricultural Policy, employment in the EC-10 would rise on the order of 2-4 million people (Stoeckel and Breckling 1988). Results for Germany indicate that liberalization of agriculture would create 850,000 new jobs and raise gross domestic product by 3 percent and exports by even more. Net exports of investment goods by the mechanical engineering and electrical engineering industries, for example, are predicted to rise by 12 and 16 percent, respectively (Donges et al. 1988). Since similar findings are reached for other countries and industries, and on the basis of different model structures, they seem to be rather robust.

What still needs to be done, however, is to disseminate these results. Given the high degree of organization of industry and labor relative to consumers, this should not be an impossible task.³⁶ Once the basic facts about intersectoral linkages are fully understood, industry and other sectors in industrialized countries may become sufficiently motivated to stand up against agricultural protection and hence provide a viable countervailing power against the farm lobby. For governments this would provide a type of protective shield against overly zealous demands by the farm lobby similar to that of international obligations that are backed by the threat of financial compensation requirements or retaliation.

The countervailing power from industries and organized labor versus the farm lobby can be maximized when trade reform in agriculture, as well as other highly protective sectors such as textiles and clothing, is linked in one package deal with liberalization and hence with the prospect of trade expansion and higher profits in most of manufacturing and the services.³⁷

³⁵ This is the conclusion that can be drawn from the various analyses conducted for the Global Agricultural Trade Study, organized by the Centre for International Economics, Canberra, Australia. The research findings are summarized in Centre for International Economics 1988. Earlier studies on this topic are summarized in Winters 1987a.

³⁶ For example, the message seems already to have reached the influential Federation of German Industry, which recently came forth with some reform proposals of its own for agriculture. See Bundesverband der Deutschen Industrie 1987.

³⁷ See Baldwin 1987. In this context it has to be remembered that higher profits result not only from better market access in foreign markets, a prospect of interest primarily to exporters subject to significant trade barriers, but also from cost reductions due to cheaper intermediate inputs and more competitive factor prices in the wake of liberalization, a point of potential interest to all firms.

Such a single cross-sectoral reform package makes a successful completion of the Uruguay Round a lot more likely than an array of separate sectoral accords.

Apart from stimulating countervailing power against a resisting farm lobby and hence enhancing the acceptability of trade reform *within a given country*, such a cross-sectoral approach to trade reform also strengthens the prospects of balancing requests and offers for concessions *between countries*. This subject was discussed above in relation to developing countries trading more openly with industrialized countries in the areas of services and manufacturing in exchange for better market access in agriculture.

Up to the middle of 1988, the negotiations in the Uruguay Round have not paid much attention to the need for cross-sectoral agreements (see the discussion in Chapter 3). The idea of a package-deal negotiating strategy, however, has been brought up in the Negotiating Group on Agriculture—although not in the form of cross-sectoral deals as suggested above, but in the form of a sector-specific deal. The United States has made the package-deal idea part of its reform proposal for agricultural trade.

The aggregate approach proposed by the United States implies that the farm policies and programs affecting all agricultural commodities would be negotiated as one package. This certainly represents a step in the right direction, although whether an intrasectoral package-deal approach is sufficient may be questioned. It presupposes that one commodity group in favor of liberalization can countervail the political power of another one that is opposed. This idea may work in the United States, but what about Japan, for example? Is there any commodity group in Japanese agriculture that could provide enough countervailing power to effectively counteract the strong opposition of rice farmers to more open markets in agriculture? If there is no such group, then countervailing power can only come from outside of agriculture, assuming consumers cannot be counted on.

At any rate, the aggregate approach suggested by the United States certainly contrasts sharply with the procedure followed in previous multilateral trade negotiations that proceeded commodity by commodity. The latter approach appears to be still favored by the EC and is also clearly the one favored by the farm lobby. The representatives of farm interests are naturally disposed against cross-sectoral arrangements, a unifying principle for the trade negotiations, or even an aggregate negotiating approach limited to agriculture. These negotiating structures strengthen the countervailing power against either farm interests in general, as in the case of a cross-sectoral approach, or the interests of specific commodity groups within agriculture, as in the case of an aggregate approach to agriculture. This has become very clear, for example, from the response of certain U.S. commodity and farm group representatives to the U.S. proposal. The aggregate approach favored by the U.S. administration has been met with open resistance from some powerful commodity groups. Several groups considered themselves simply too special to be dealt with in a package deal. Others voiced their concern that U.S. negotiators would not focus on the best interests of a particular commodity group in such negotiations but would instead consider overall U.S. benefits in agriculture (see U.S. General Accounting Office 1988, 31-32).

In short, more emphasis on cross-sectoral negotiations and compromises appears to be critical to eventual achievement of the objectives stated in the Punta del Este Declaration. This requires, however, some changes in the procedural foundations of the Uruguay Round. First, the trade talks are in urgent need of a unifying principle, one that is applicable across all sectors. It could perceptively facilitate cross-sectoral compromises and, at the same time, force disclosure on all negotiating groups. (See Nau 1987 for a similar proposition, and GATT Secretariat 1984a, 1.)

Second, government representatives at the highest echelon have to be more directly involved in the negotiations. Their involvement has helped significantly in getting the Uruguay Round started in Punta del Este. It is needed again midway through the Uruguay Round. Only at

the highest government level is it possible to agree on the core of GATT reforms, that is, on a unifying principle or formula similar in spirit to the 'across-the-board' tariff-reduction idea of the Tokyo Round. Experts from agriculture or other sectors cannot be counted on to achieve much progress on their own. They operate in a direct shooting line from their sectoral clientele. This special relationship makes it difficult for them to agree to more than marginal adjustments of the present system. Far-reaching changes that extend beyond the sector, and hence could generate compromises at a higher level, need the involvement of nonspecialists who are able and willing to see beyond narrow sectoral concerns.

THE THEORETICAL CONSEQUENCES OF CHANGING CERTAIN GATT PROVISIONS

Restricting the Use of Export Subsidies

In contrast to trade in manufactures, where export subsidies are explicitly prohibited by the GATT, export subsidies have become a frequently employed trade instrument in agriculture. Their main use has been to help industrialized countries such as the EC and the United States dispose of domestic production surpluses resulting from policies that support the domestic market price above its free market level.³⁸ The subsidies have enabled subsidizing countries to expand their exports at the expense of nonsubsidizing industrial countries such as Australasia and, above all, developing countries. Such is the case, for example, for beef and veal as well as sugar. A comparison of the average market shares for 1970-74 with those of 1980-84 shows that the OECD countries have expanded their export market share of beef and veal from 40.3 percent to 62.1 percent, while that of developing countries dropped from 52.1 percent to a mere 26.9 percent. The figures for sugar indicate an increase in market share for OECD countries from 17.0 percent to 28.5 percent and a drop from 73.8 percent to 67.4 percent for developing countries (Organisation for Economic Co-operation and Development 1987, 220, 226). Although some of the decline in market share for developing countries can probably be attributed to overvalued exchange rates and other similarly unfavorable domestic conditions for exporters (see Krueger, Schiff, and Valdés 1988), the larger part of the market share decline is certainly due to export subsidization combined with import protection in industrial countries.

The wide range of suggestions on how to solve the issue of export subsidies includes proposals on limiting their negative trade effects by fixing market shares, as well as proposals aimed at restricting their use. The latter proposals extend from a complete prohibition of subsidies to allowing them subject to certain restrictions.

Strengthening the Equitable Market Share Rule

Many, if not most, of the trade conflicts in agriculture have arisen because the equitable market share rule, which conditions the use of export subsidies for primary products, has turned out to be too general to be ascertained objectively. The evidence accumulated by GATT panels that addressed the issue of equitable market shares demonstrates that it has not been possible to find operationally meaningful criteria for what constitutes an equitable market share.³⁹ As a result, the market share rule has been rendered meaningless for all practical purposes. Taking

³⁸ Whereas the EC has long subsidized exports for numerous agricultural commodities, export subsidies by the United States have become more frequent only since the passage of the 1985 Farm Bill. Since then, exports of beef, dairy products, sugar, wheat, rice, corn (maize), and cotton have been directly or indirectly subsidized via the Export Enhancement Program, the Marketing Loan Program, deficiency payments covering all production rather than only domestic consumption, and various other devices. See Hathaway 1987.

³⁹ So far, four GATT panel decisions have involved the equitable market-share rule. In the Australia versus France dispute on French wheat flour exports of 1959, the GATT panel concluded that export subsidies had expanded France's market share to a more than equitable level. No conclusive decision was reached in the subsequent three cases—Australia versus the EC and Brazil versus the EC on EC sugar export subsidies in the late 1970s, and the United States versus the EC on EC wheat flour export subsidies in 1983.

this as the point of departure, redefining the equitable market share rule in the direction of improved operational effectiveness seems to be a natural suggestion for reform. The basic premise behind the proposal to refine rather than discard the idea of market sharing is the notion that focusing the negotiations on the outcome of government interventions as they relate to trade flows—in particular, changes in export market shares—can be more easily achieved than trying to define export subsidies and then to outlaw or otherwise restrain their use. Although this focus on the ultimate trade effect of government intervention in trade is very much in the spirit of the GATT, it remains to be seen whether this can be said also of the conceivable ways of implementing a refined market share rule.

Ways to make the market share rule more operational have been deliberated on in some detail by the Committee on Trade in Agriculture. The suggestions developed in these discussion rounds rely in one form or another on predetermining exports in numerically fixed form for the major commodities and exporters. Market sharing in the conventional sense would imply that an exporter's share in world exports would be limited to a particular percentage. An alternative proposal would fix the exports of a given country in a particular commodity to a fixed tonnage amount that is related to past export performance. For example, the export quota could be set equal to exports in the past year or to average annual exports in the past five-year period. In contrast to the conventional export market share idea, this method has three distinct advantages: the amount of uncertainty for nonsubsidizing exporters would be reduced; verification would be made easier both in terms of data requirements and of the time lag between the end of the trading year and the necessary review of the export performance; and, perhaps most important, taking advantage of world export growth would be reserved for nonsubsidizing countries, allowing them to capture at least some of the effect of their competitive advantage. To avoid the problem of legitimizing existing market shares acquired through unrestrained past subsidization, modifying the above approach by replacing actual historical market shares with negotiated ones could be considered.

On the positive side, market-sharing arrangements of the above type would clearly cause few definition or measurement problems. They are also fairly easily monitored, although unfortunately only after the fact in many cases. (For commodities that are exported fairly evenly over the course of a trading year, monitoring is possible before the end of the year.) A possible problem could develop, however, for those commodities for which nonsignatories of the GATT supply a major share of world exports, such as Cuba for sugar. Another advantage of fixed export market shares is their resilience to avoidance strategies on the part of exporters. Regardless of what form of government intervention is applied by a given country, its end result, the actual trade volumes, cannot be manipulated. (Exporters could, however, switch to higher-quality exports, which might infringe on the interests of other exporters.) In principle, fixed export quantities or shares are also resilient to long-run changes in supply and demand. Increased productivity of subsidizing countries, for example, would have no effect on other countries, yet would increase the financial burden on price-supporting governments. Productivity increases in nonsubsidizing countries would mean either higher government outlays or lower farm prices for farmers in subsidizing countries. In either case, there would be an incentive to lower price supports and hence subsidies.

Market-sharing agreements are similarly without problems from the political-economy perspective. They clearly cater to the interests of the farm lobby because they are likely to involve only marginal adjustments for farmers, not the establishment of a completely new and unfamiliar incentive structure, with possibly significant economic losses for fixed factors in the short and medium runs. For example, there would be no pressing need for the EC to abandon the principles of its Common Agricultural Policy. The system of variable levies and export subsidies could be left essentially intact, although the requirement to maintain export market shares at present or slightly reduced levels would force more discipline upon demands

of farmers for increased support prices. Politically then, market sharing would seem to be very attractive. Such a proposal for agricultural trade reform would be almost guaranteed smooth sailing through the legislatures of subsidizing countries because domestic opposition to such a solution would be weak, at best. After all, consumers are unorganized and other industries or sectors that could gain from agricultural trade liberalization would be dealt with in separate arrangements, fully delinked from agriculture. Overall then, there appear to be several arguments strongly in favor of market-sharing agreements, or what is sometimes called "managed trade."

Market-sharing agreements can be criticized on two grounds. First, they do not have a successful track record. The experience with various commodity agreements for wheat, cocoa, and coffee suggests that they do not last very long. Usually they run into trouble over problems of long-run demand and supply effects. In theory, strong increases in productivity combined with stagnant world demand would call for internal adjustments in the form of lower production in subsidizing countries. In practice, however, production is often not curtailed, thus leading to declining world prices and ultimately to a breakdown of the commodity agreement itself. In other words, market-sharing arrangements can work quite smoothly in the face of strong demand growth, but they hardly ever survive the double blow of stagnant or diminishing demand and growing supply.

Second, market sharing in agriculture would strongly contradict two basic GATT principles: nondiscrimination and reliance on the price mechanism for trade restrictions. Countries that mainly export agricultural products would be put at a clear disadvantage compared with countries that mainly export manufactures. Only the former would be constrained in their exports, being able to make use of their comparative advantage only at the margin and starting from an artificially low base. Fixed export quantities would allow an efficient resource allocation, both within countries and among countries, only for that part of world trade that results from future demand growth, not for current levels of world trade. If demand growth is expected to be low, as is the case for numerous agricultural commodities, little export expansion is possible for efficient exporters unless the export share or export quantity granted to subsidizing countries is reduced over time.

Negotiating and then fixing export quantities or shares for a large number of countries and commodities years into the future is no small task. In all likelihood, this would involve arrangements outside the confines of the General Agreement and very similar in principle to the Multifiber Arrangement in textiles and clothing. This assumes that an arrangement could be reached at all. In this case, however, agriculture would have become the second area subject to managed trade. Such a development could severely weaken the GATT system and its credibility, not only in the eyes of nonsubsidizing countries but also in the eyes of sectors and industries that are still subject to GATT disciplines. Extending a system of managed trade to agriculture would confirm that export subsidies pay off after all in the sense that, eventually, the market share achieved this way will be vindicated by international agreement. It would also send a strong signal to the effect that hard lobbying is really all it takes to eventually receive special treatment, that is, to gain relief from the forces of international competition. Special conditions, which supposedly make agriculture a unique case and thereby justify this special treatment, can surely be claimed also by other industries and sectors.

Prohibiting Export Subsidies

Instead of developing further the existing rules on export subsidies in agriculture, a more drastic solution may be chosen—disallowing export subsidies altogether, with some well-defined exceptions. The rationale for this can be understood in light of the disappointing experience with the equitable market share rule discussed above and the largely ineffective attempt to "strengthen" the GATT rules on export subsidies through the introduction of the Subsidies

Code negotiated during the Tokyo Round. (Hufbauer and Erb [1984] provide a discussion of this code.)

Some Theoretical Preliminaries. Export subsidies affect the terms of trade of trading partners. In particular, they improve the terms of trade of importing countries. Consumers in importing countries experience a welfare gain. This is the reason that net importers of grains, among them many low-income developing countries, do not favor an end to all export subsidies. If all else remained the same, ending these subsidies would worsen the net importers' terms of trade. The *ceteris paribus* condition, however, is questionable. By raising the profitability of the subsidized product, export subsidies divert resources away from other uses, that is, from industry in the case of agricultural export subsidies. In short, agricultural export subsidies raise the world market price of industrial goods relative to agricultural goods. Hence an end to agricultural export subsidies is likely to lower the relative price of industrial goods. If industrial countries have a comparative advantage in industrial products relative to agricultural products and vice versa for many poor developing countries, a ban on agricultural export subsidies can therefore improve the allocation of resources without negatively affecting the terms of trade of developing countries, at least in the medium to long run.

For the export-subsidizing country, a general export subsidy is equivalent to a general import subsidy, barring any deviations from the conditions of long-run general equilibrium.⁴⁰ An export subsidy can therefore serve a useful purpose: it can compensate for import restrictions.⁴¹ Applying this idea to the two broad sectors of agriculture and industry means that export subsidies on agricultural products could be used to compensate for the negative effects on domestic resource allocation of import restrictions for industrial goods. This argument for export subsidies may have some validity for developing countries. Many of them continue to protect import-competing industries heavily, thereby levying a hefty tax on agriculture (see Krueger, Schiff, and Valdés 1988). Yet export subsidies are seldom observed. One obvious reason is their high budgetary cost. But even if funds were plentiful, the removal of import protection is certainly the obvious best choice rather than an attempt to counteract one distortion with another. For industrial countries, export subsidies on agricultural products can be even less justified by import restrictions outside of agriculture. As discussed at some length in Chapter 3, agriculture is generally more protected than industry (there are some exceptions, such as Australia). Hence, industrial goods rather than agricultural products would have to be subsidized in most industrial countries.

In short, the theoretical reasons against a ban on export subsidies appear of little practical importance for either developing or industrial countries.

The Scope of a Prohibition on Subsidies. Before the potential trade effects of a prohibition of export subsidies can be analyzed, it is necessary to define the scope of such a subsidy ban. As the discussions of the Committee on Trade in Agriculture have made clear, this issue is in itself far from settled. Two basic approaches are seriously considered: defining export subsidies in a comprehensive way, and treating agricultural goods like nonprimary goods.

A comprehensive definition of export subsidies would include all indirect subsidies as long as they operate to increase agricultural exports. Included in such a comprehensive prohibition would be any form of price and income support to farmers, making avoidance behavior of governments difficult if not impossible, at least in theory. However, it is clear that it would be difficult to draw the line between subsidies that affect exports and those that do not, especially because a number of subsidies are well known to have a distinctly different effect in the long

⁴⁰ This is the essence of the well-known Lerner symmetry theorem. See Lerner 1936.

⁴¹ Export subsidies increase domestic prices for exportables relative to importables. This is equivalent, in principle, to a decrease in import prices or a subsidy on importables.

run as opposed to the short run. Subsidies for research and extension as well as infrastructure, for example, are in this category. Hence, if an all-encompassing definition of prohibited subsidies is applied, it may be wise to add an illustrative list of government assistance measures that are exempted from the subsidy ban. Such a list could include support payments with only indirect links to trade, such as deficiency payments on domestically consumed production or cash payments unrelated to production. A general prohibition of subsidies could thus be made more manageable, and the unwanted effect of preventing domestic agricultural policy reforms that are in the interest of world trade, such as a switch from market price support to income support, would be minimized.⁴²

A comprehensive definition of illegal export subsidies is less appealing because it would again give agriculture a special status, although with the policy on subsidies completely reversed from the lax rules that obtain currently. As the rules on subsidies would be more stringent in agriculture than in any other sector or industry, such a reform proposal seems unlikely to have a realistic chance in the legislatures of industrialized countries. Simply extending the prohibition of export subsidies on nonprimary goods contained in Article XVI:4 to agriculture seems to be the most appealing solution. (This would imply that the Subsidies Code be changed accordingly.) First, it would mark a move toward a more consistent GATT treaty. With agriculture losing its special status and trade reforms consequently being negotiated for all trade, possibilities of true progress in international trade relations could be opened up (see the discussion of political-economy considerations in Chapter 4). Second, surveillance and enforcement would be made easier compared with the first option. For countries that have signed the Subsidies Code, its more detailed provisions would be binding, including the illustrative list of prohibited export subsidies (see Appendix 2). For all other signatories of the General Agreement, Article XVI:4 would be relevant, linking export subsidies to the existence of a positive price difference between domestic price and export price. This latter definition of export subsidies will form the basis of the discussion in this and the following chapter.

The Trade Effect of Discontinuing Export Subsidies. To analyze the trade impact of a discontinuation of export subsidies, it will be assumed that they serve to dispose of domestic surpluses generated by a policy of import protection in combination with price guarantees to farmers. As already mentioned, this is likely to be the most important application of export subsidies in agriculture. A typical example is the Common Agricultural Policy of the EC for wheat and beef. Without a change in the system of market price support, a discontinuation of export subsidies would involve a policy choice between accumulating ever-growing stocks, destroying excess supplies, or shipping the excess overseas as food aid. All of these methods have in fact been used for one product or another by countries with surpluses, sometimes substituting for and sometimes accompanying subsidized exports. If it is recognized that none of these methods offer viable long-run solutions, the cause of the surpluses, that is, the method of market price support, has to be changed. It should come as no surprise that there is a multitude of options available to countries to react to a general ban on export subsidies, with each alternative having a potentially different trade effect. In trying to identify some likely reaction patterns, it is helpful to distinguish between behavioral adjustments working primarily on the demand side and those affecting mainly the supply side.

One solution to the excess supplies problem and one very much in the spirit of a free market approach would be to lower support prices and frontier barriers to a level where the domestic

⁴² An interesting scheme of decoupled income payments was suggested in the Boschwitz-Boren Bill, which was considered for the 1985 U.S. Farm Bill but was ultimately defeated. It called for gradually declining "transition payments" to farmers, based on past acreage and yield, with high payments at the beginning to offset losses during the adjustment toward market-oriented farming. See Paarlberg 1987, 118-120.

price coincides with the price that just clears the domestic market. In contrast to a pure demand- or supply-side policy, this approach would have both a negative production and a positive consumption effect, reinforcing each other in curbing excess supplies. The trade effect of such a change in domestic policy would operate only on the world export supply schedule—not on world import demand. Subsidized exports would be eliminated, thereby shifting the world export supply curve to the left and causing, *ceteris paribus*, an increase in world price. As the specified country would not turn into an importer, world import demand would be unchanged. Nonsubsidizing exporters would benefit not from better access to the country but from the fact that competition from subsidized exports in third markets would cease.

To make a policy of lower protection levels socially acceptable, income transfers would be called for. To minimize unwanted production effects, transfers would have to be personalized, limited to the current generation of farmers, and not bound to specific production decisions of farmers. Payments under this scheme are simply intended to maintain income, leaving it to farmers to adjust production fully to market conditions. To take the stigma of welfare payments out of decoupling, payments could be linked to the idea of structural adjustment. Transfer payments could be made at one time or at a continually decreasing rate over time to make up for the loss in land values associated with an elimination of market price support policies or the need to move out of agriculture or both.

Decoupling is still likely to meet with resistance from the farm lobby because it has to be funded out of general tax revenue, thereby making farm policy highly visible and subject to annual budgetary scrutiny. From a trade perspective, this is obviously exactly what is intended, because for nonsubsidizing countries it ends the uncertainty associated with open-ended support programs by subsidizing exporters. In this context it may also be noted that farmers are not the only ones with a vested interest in the continuation of present policies. The industries upstream and downstream from agricultural production and basically the whole rural economy are to some extent benefiting from current farm support policies (see Koester and Nuppenau 1987). Hence, compensating farmers alone may not be sufficient to get a sweeping trade reform bill passed by the legislature. As discussed in Chapter 4, strong support in favor of trade reform may have to come from outside of agriculture.

A pure demand-side policy would try to solve the problem of excess supplies by stimulating domestic demand for the product in question. This could involve any combination of a variety of methods, such as selectively lowering consumption taxes on that good, its complements, or the products it enters as input; raising taxes on substitutes, in raw or processed form; subsidizing new demand niches;⁴³ and restricting import demand for substitute products or their complements, again in raw or processed form.

For the product in question, each of these pure demand-side policies results in a shift to the right of the domestic demand curve. Depending on the price elasticities of demand and supply, the supported market price prior to the policy shift could be maintained, making income transfers or deficiency payments unnecessary. In contrast to a policy response based on a reduction in protection levels, the degree of protection need not change. The trade effect would be the same in both cases, as long as the view is restricted to the product in question. However, the trade effect of the two policy responses may differ appreciably if the analysis is extended to include the other products, complements, and substitutes that are influenced. In particular,

⁴³ An example would be to subsidize the conversion of "natural resources" such as cereals or sugar beets into a fuel substitute, or of milk into butter or cheese. Such a subsidy would be equivalent to an input subsidy on the end product, with the possible effect of increasing exports of the derivative, again at the expense of nonsubsidizing exporters. Hence, the excess-supply problem would simply be shifted to a different market.

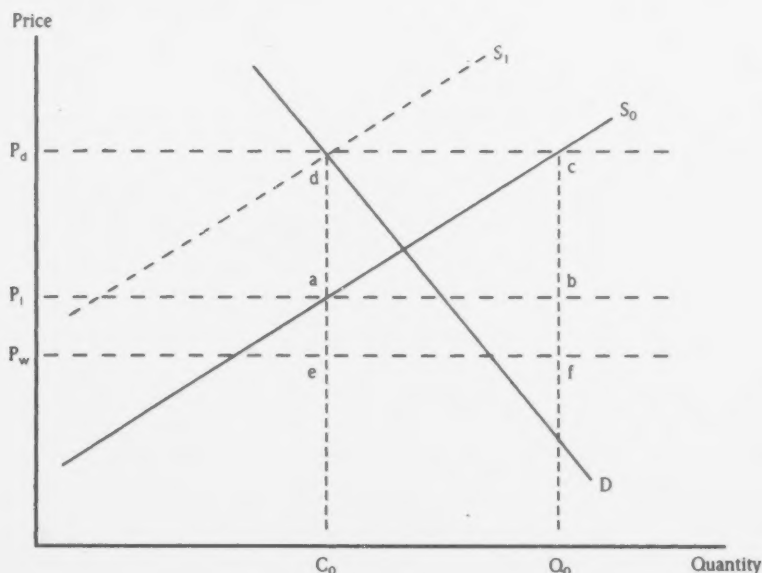
imports of the indirectly affected products would decline, either because of an increase in their import protection or because of government-induced changes in their relative prices.

Whether the rest of the world would be better off with or without such a policy response is unclear *a priori*. What is certain, however, is that the overall trade effect would be worse for pure demand-side policies than under a policy of reduced protection levels. It may also be noted that demand stimulation alone would probably not suffice to eliminate substantial excess supplies, for example, those experienced by the EC over the past decade in products such as beef and sugar. The reason is that domestic own-price or cross-price elasticities of demand are generally considered to be quite low for primary agricultural products.

Pure supply-side policies would attempt to curb production to eliminate excess supplies, leaving the nominal protection level constant. Input subsidies could be reduced for that purpose, tariffs could be raised on imported inputs, or production could be taxed. Either policy would shift the domestic supply curve up to the left, from S_0 to S_1 in Figure 3, assuming the implicit tax on producers equals distance ad . An implicit tax of that size would ensure that the domestic market clears without a reduction in the nominal protection level. The trade effects resemble those of a pure demand policy: subsidized exports cease, while imports remain zero. This is the partial equilibrium result. However, as in the case of pure demand-side policies, there may be unintended effects on related products. For example, restricting implicit taxation to product A may induce farmers to shift resources to product B. Even though the need for export subsidies is eliminated for product A, imports for product B may now be lower than before, thereby hurting the interests of countries exporting B. Hence, an implicit tax on isolated products may only shift, not eliminate, the problems caused by high domestic support prices and frontier barriers.

For domestic farmers, a pure supply-side policy based on implicit taxation is decidedly inferior to a pure demand-side policy. Their producer surplus, that is, the area between price line P_d

Figure 3—Pure supply-side policy



and the supply curve,⁴⁴ diminishes under implicit taxation, whereas it remains constant under a demand-side policy. Hence, closing the gap between supply and demand at support price P_d through a policy of implicit taxation appears politically difficult. Probably the only way to achieve it is by compensating farmers for their losses through cash payments and, at the same time, building up strong support for a change in agricultural policy outside of agriculture. As discussed in Chapter 4, creating such support requires, among other things, embedding agricultural policy reform within the context of a multilateral trade agreement that encompasses all trade and is balanced across sectors.

Acreage reduction is an alternative to implicit production taxes if export subsidies are prohibited but support prices cannot be reduced for political reasons. Acreage reduction programs are certainly favored by farmers. Such programs have a long tradition in the United States, but they also appear to be gaining popularity in the EC. In fact, the agricultural policy in the EC seems to be drifting in this direction even without a ban on subsidies, because acreage reduction or set-aside is seen as a way to reduce the budgetary costs of farm support.⁴⁵ Set-aside programs can operate in a number of ways. A direct incentive system as practiced in the United States from 1956 to 1958 under the name of Acreage Reserve Program, or one similar to the diversion program in effect since the 1960s, involves paying farmers a specified premium per acre taken out of production. (The set-aside program presented by the EC Commission in early 1988 also falls into this category.) The predominant acreage reduction scheme in the United States since the 1960s works instead via indirect incentives. Rather than paying farmers for each acre taken out of production, the government subsidizes the remaining acreage used for continued production with deficiency payments. The deficiency system will be addressed later. For the moment, the discussion will be restricted to the direct incentive system.

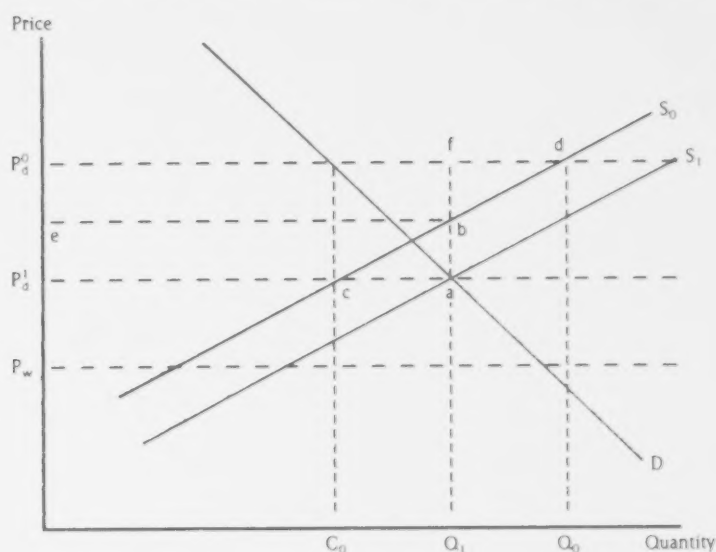
Figure 3 helps to explain the basic idea behind the direct incentive form of set-aside programs. A premium equal to $(P_d - P_i)$ per production unit is paid to farmers in order to reduce domestic production from Q_0 to C_0 and hence eliminate the need for subsidized exports. Compared with the case of export subsidies in the amount of $efcd$, producers gain from the acreage reduction scheme. They are better off by triangle abc . The costs to the treasury are lower by rectangle $efba$. There are some practical problems, however. In reality, the premium is paid not for production units forgone, as assumed above, but per land unit taken out of production. Reducing acreage, though, does not necessarily imply that production diminishes by the intended amount $(Q_0 - C_0)$. At least this has been the experience in the United States with acreage reduction programs. The simple reason is that farmers intensify production efforts on the remaining land. What happens to the land taken out of production also plays an important role. If it can be used to produce other agricultural commodities, acreage reduction for one product may simply lead to more exports or lower imports in another product. For all commodities taken together, then, there may be little gain to exporters of nonsubsidizing countries.

What remains to be discussed is policy responses that combine elements of a supply-side policy with changes in the nominal protection level. One such policy response would consist of substantially reducing or even eliminating import protection and at the same time raising input or production subsidies sufficiently. Figure 4 illustrates such a case. The level of protection is lowered so that the domestic price drops from P_d^0 to P_d^1 . As partial compensation for farmers, a unit production subsidy of size ab is put in place, thereby shifting the domestic

⁴⁴ S_0 is relevant before and S_1 after implicit taxes are imposed.

⁴⁵ See *Agra Europe*, January 22, 1988, P/1 - P/3. The EC Commission seems to endorse this shift. For example, it has drawn up an elaborate acreage reduction plan for cereals. See *Agra Europe*, January 15, 1988, P/1, for a summary of the plan's provisions.

Figure 4—Partial replacement of import protection with domestic subsidies

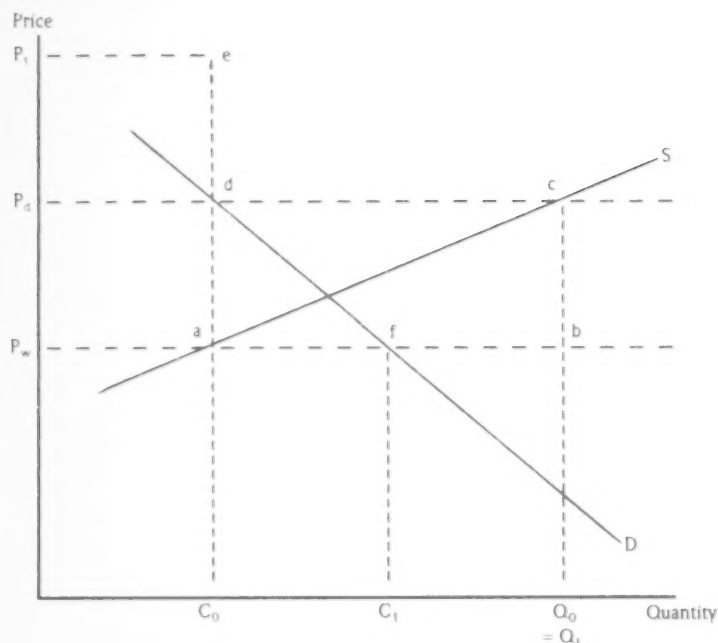


supply curve to the right. Domestic production declines from Q_0 to Q_1 , and consumption rises from C_0 to Q_1 .

The trade effect of such a policy parallels that resulting from a pure demand or supply policy: imports would remain at zero, and exports would decline to zero. The switch from a trade regime characterized by high protection and export subsidies to one of low protection and production subsidies affects the rest of the world only via a change in world export supply. Less will be exported at subsidized rates but no more will be imported. Whether such a policy response is found acceptable by farmers depends on the size of the subsidy relative to the reduction in nominal protection and the relevant demand and supply parameters. For example, a subsidy of size ab is clearly insufficient to compensate farmers fully for the reduction in market price support from P_d^0 to P_d^1 . (As S_0 is linear, area abc equals area bdf , so farmers lose area $bdfP_d^0e$ as a result of this policy change.) Consumers clearly benefit because they face lower prices. Government expenditures are now in the form of production subsidies rather than export subsidies. Whether expenditures rise or fall is not clear a priori.

Instead of substituting domestic subsidies for export subsidies, a two-price system could be introduced. The essence of a two-price system can be explained by reference to Figure 5. Before the elimination of export subsidies, exports equal quantity $(Q_0 - C_0)$ at domestic support price P_d . The domestic price is maintained at level P_d through sufficiently stringent import restrictions (in the case depicted, this could be a zero import quota or a prohibitive tariff). The export subsidy amounts to area $abcd$. Switching to a two-price system has somewhat different implications, depending on the way it is administered. Governments have two basic choices. Under the first option, the government restricts domestic sales to C_0 to keep the domestic price from falling below P_d . The size of the per-unit deficiency payment to farmers $(P_1 - P_d)$ is then determined by domestic supply conditions. Under the second option, the government fixes instead the per-unit deficiency payment $(P_d - P_w)$ and farmers respond by setting the quantity produced (Q_1).

Figure 5—Two-price system

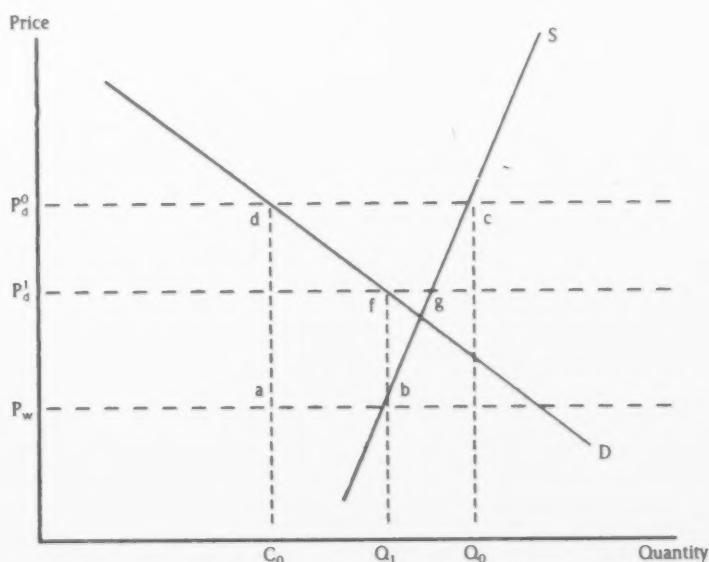


Some comments are in order on the first option. To restrict domestic sales to C_0 the government can intervene in a number of ways. One of the more efficient ways would be to distribute marketing certificates to farmers based on their production levels in some base period. Making these certificates freely tradable and tying their ownership to the deficiency payments would avoid production distortions characteristic of such schemes as equal percentage production cutbacks for all farmers or the U.S. version of deficiency payments (see Hathaway 1987). In particular, to be eligible for deficiency payments, inefficient farmers would not be required to continue producing, and efficient farmers would not have to idle productive land. Under the scheme, farmers would be free to produce as much for export as they want. The point is, though, that they face the world market price for any production beyond C_0 . For all units up to C_0 , farmers receive as deficiency payment the difference between the market-clearing price P_d and some target price P_t . Price P_t has to be sufficiently above P_d to compensate farmers for the loss in producer surplus identified by area acd . Per-unit deficiency payments would have to be at least equal to distance $P_t - P_d$. Productivity increases in combination with slow demand growth would enlarge area acd in Figure 5, thereby raising the price P_t needed to compensate farmers. Compared with the system based on export subsidies that this version of a two-price system replaces, government expenditures diminish because the deficiency payments covering the loss in producer surplus (deP_tP_d) are lower than the former export refunds ($abcd$). The funds the government saves are equal to some share of the resource cost of the former level of production. (The switch to a two-price system is saving the government revenue equal to area abc in Figure 5.) Consumers are unaffected by the switch in support policies. They continue to pay price P_d and thus continue to bear much of the cost of farm support.

Under the second option for deficiency payments, it is assumed that all frontier barriers to trade are dismantled. Hence consumers face the world price P_w and consume quantity C_1 . In contrast to the first case, they do not share in the costs of farm support. The burden is fully shifted to taxpayers. As a result, government expenditures exceed those realized under the first option discussed above by the implicit tax paid by consumers under that scheme (adP_dP_w). Another crucial difference is that deficiency payments are not limited to a particular quantity as they are under the first option. Rather they are paid on all production units, regardless of whether part of that production is exported or not.

The trade implications of the two types of deficiency payment schemes are different. Under the first option, imports remain below their free trade level for countries that would be importers under free trade ("natural" importers).⁴⁶ For example, in Figure 5, which depicts the case of a natural importer, free trade imports equal distance af . Under the two-price system no imports occur. Hence, for imports, there is no change compared with the situation that obtained under a system of price support cum export subsidies. In the case depicted in Figure 5 there would also be no exports under the deficiency payment scheme. It would simply not pay for farmers to produce in excess of C_0 because their production costs are in excess of the prevailing world price for units beyond C_0 . This result is independent of the size of the deficiency payment per unit as long as deficiency payments are paid only on the domestically consumed quantity. Hence, for exports, the first option of the deficiency payment scheme appears to compare favorably with the price support cum export subsidy regime for which exports were of size $Q_0 - C_0$. However, there is a caveat. There could be cases for which exports would not cease under this option. Such a case is depicted in Figure 6.

Figure 6—Two-price system with implicit export subsidization



⁴⁶ Exports are lowered to their free-trade level for "natural" exporters, that is, countries that would export under free trade.

At price P_d^0 , consumption equals C_0 in Figure 6. In analogy to Figure 5, C_0 is the quantity supported by deficiency payments. (The deficiency payments for the case depicted in Figure 6 would amount to area abcd.) In contrast to Figure 5, though, total production (Q_1) will now exceed the quantity that receives deficiency payments (C_0). The difference ($Q_1 - C_0$) can be produced profitably at world price P_w and exported without the help of explicit export subsidies.⁴⁷ Although exports are lower than under the price support cum export subsidy regime, thereby providing third-country exporters with somewhat better trading opportunities, there is still the peculiar situation that a natural importer is exporting, and this without any apparent explicit export subsidies. Exports are possible, however, only because the government is committed to deficiency payments that are related to a very high level of protection relative to the particular shapes of the domestic demand and supply curves. Deficiency payments serve the function of an indirect export subsidy in this case. The indirect subsidization of exports would not occur if the government were committed to deficiency payments only relative to a lower level of protection than indicated by P_d^0 . In particular, exports would cease for a protection level corresponding to price P_d^0 or below and matching deficiency payments equal to area bfg or less. To sum up, the first option of implementing a deficiency payment scheme does not prevent countries that are natural importers from continuing to export the protected commodity in all possible cases. Indirectly subsidized exports can be prevented only if import protection is reduced at the same time that deficiency payments are limited to domestic consumption. The latter action alone is not sufficient to prevent indirect export subsidies.

Under the second option for deficiency payments, import protection is eliminated. Hence the type of indirect export subsidization described above cannot occur. However, there is still the possibility of indirect export subsidies. They can occur because the deficiency payments are not limited to domestic consumption but apply to all production. As per-unit deficiency payments ($P_d - P_w$) are granted for quantities beyond C_0 , domestic producers face an effective price of P_d for any quantity they choose to produce (Figure 5).⁴⁸ Accordingly, they extend production to Q_1 . As domestic consumption is considerably lower, at C_1 , the difference, that is distance $Q_1 - C_1$, will be exported. Over time, as productivity increases and the supply curve shifts to the right at a more rapid rate than the demand curve, exports will even expand. In short, even in the absence of import protection, deficiency payments can have a trade effect that is very similar to the one that obtains in a system based on border protection and export subsidies. This can occur when fairly high deficiency payments are provided for all units of production, regardless of whether they are exported or not. This is basically what characterizes the U.S. deficiency payment system for grains, although its details are somewhat more complex. For instance, U.S. farmers receive deficiency payments only if they agree to restrict their acreage. This means that total production would be at a level below Q_1 in Figure 5. Also, total deficiency payments per farm are generally restricted. Finally, for most grains, Figure 5 would have to be changed somewhat to provide a more realistic description of the domestic U.S. market. In particular, the world price (P_w) would have to be set equal to the price level marked as P_d in order to depict the case of a natural or efficient exporter.

To sum up, a ban on export subsidies could be expected to have the following benefits. (The main objections to a ban on export subsidies were discussed under "Some Theoretical Preliminaries" earlier in this chapter.) Efficient exporters, that is, countries that would be net

⁴⁷ Clearly, farmers will export only if the government can prevent them from selling $Q_1 - C_0$ in the domestic market, in which case the domestic market price would drop to P_d^0 . Government enforcement is likely to be possible if the commodity has to go through a particular processing or marketing channel. This is the case, for example, with sugar.

⁴⁸ Distance ($P_d - P_w$) equals distance ($P_1 - P_d$).

exporters under a free trade regime, would face less competition in their export markets from directly subsidized exports. Hence they would not have to support agriculture as much anymore to counteract foreign subsidies, thereby freeing resources for other purposes. For a given world demand curve, the world supply curve would move to the left, thereby raising world price. Efficient exporters would benefit from the resulting increase in both world price and export quantity, although not to the extent that would be expected under a free trade regime.

Avoidance behavior, however, is still possible if export subsidies are prohibited. If pure demand-side or supply-side policies are substituted for export subsidies, without any reduction in market support prices, nonsubsidizing exporters may experience worse market conditions for products connected by either demand or supply cross-effects to those formerly subject to export subsidies. Exports of those products may drop and their world price may fall because countries that formerly imported these products on a large scale now import less or even export. Unbound tariff levels may have gone up, or voluntary export restraints may have been introduced in addition.

Unwanted trade effects may also result in the case where a deficiency payment system is substituted for export subsidies. If the deficiency payments per unit are relatively high and are provided for all production units, they may end up subsidizing exports indirectly, even if there are no import restrictions in effect. If there are import restrictions, deficiency payments may subsidize exports in an indirect way even if they are limited to the part of production that is consumed domestically. In the case of a natural importer, these indirect export subsidies are easily checked. All that needs to be monitored is the trade balance of the product in question. Evidence of any appreciable exports would signal that the ban on export subsidies, that is, indirect export subsidies, had been violated. For a competitive exporter that maintains no import restrictions, it is much more difficult to prove the existence of indirect export subsidies, especially if the exporter has a dominant influence on world price (this is typical of the United States in cereals). A pragmatic way to minimize these difficulties is to establish (for example, in the Subsidies Code) that deficiency payments shall under no circumstance be allowed on production not consumed domestically.

Policy responses along the lines of two-price systems are favored by many economists (see, for example, Paarlberg and Sharples 1984; Hathaway 1987). But as these systems generally involve the establishment of production quotas for farmers, some economists doubt their usefulness for countries other than the United States that do not have a tradition of such quotas (Henze 1985; Bergmann 1986). A system of production quotas makes considerable demands — on the availability of statistical data at the farm level, and the more small-scale farming dominates agricultural production, the larger are administrative costs. These two points seem to be of some importance for the EC. (A discussion of the problems of applying acreage reduction schemes to European agriculture is given in Henze 1985, 332-333.) However, their importance should not be overstated; if there were indeed insuperable administrative difficulties, it is unlikely that the EC Commission would have come out with a detailed plan on acreage reduction.

Finally, some comments are required on the political-economy problems of a reform proposal that prohibits export subsidies. In all likelihood it would meet with some resistance, in particular from the EC, which is by far the main user of export subsidies.⁴⁹ After all, export subsidies are a central part of the EC's Common Agricultural Policy as it has evolved. But although their removal would require the restructuring of a number of commodity support programs, there may be some hope that the EC could agree to this, assuming it would get something in return, either inside or outside of agriculture. (The issue of compensation is discussed in Chapter 6.)

⁴⁹ Adjustments would also be required by some Nordic countries, Austria, and Japan. Details on protection methods by commodity are supplied in Organisation for Economic Co-operation and Development 1987.

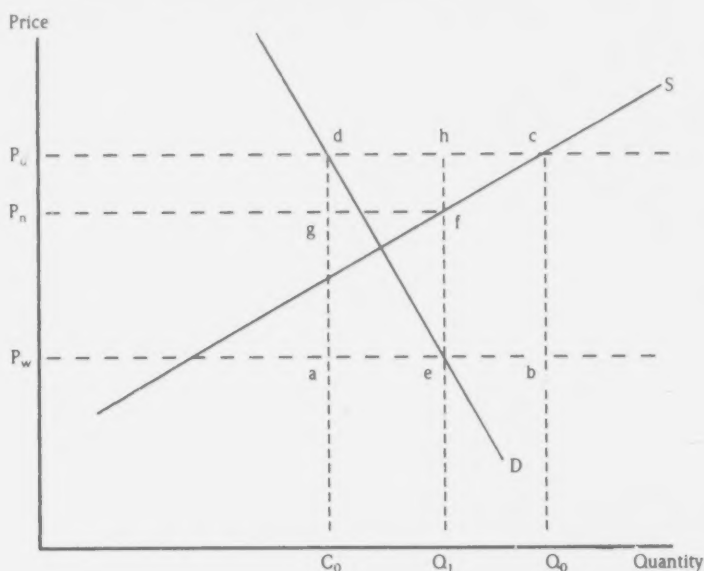
This guarded optimism stems from the EC's apparent leaning toward a system of acreage control. As shown in some detail above, however, acreage reduction can serve, in principle, as a substitute for export subsidies.

There is somewhat less need for the United States to adjust in the event of an export subsidy ban because export subsidies, although used more frequently since the 1985 Farm Act, are not central to most U.S. agricultural support programs. However, the U.S. system of deficiency payments for grains, for example, whereby payments extend to all production, would be in need of thorough reworking. Countries such as Japan or the Nordic countries, which operate highly restrictive import systems for much of agriculture but are not exporting, would of course not be required to adjust their farm support programs if export subsidies were prohibited for agricultural products. That is obviously why they have expressed essentially no objections to an export subsidy ban. (See the discussion in Chapter 3 of the reform proposals tabled by Japan and the Nordic countries at the Geneva talks in 1987.) Yet if the current disarray in agricultural trade is viewed as a result of import protection as much as of export subsidies, then a comprehensive reform proposal would have to encompass more than just a ban on export subsidies.

Allowing Only Producer-Financed Export Subsidies

In its deliberations the Committee on Trade in Agriculture has apparently come to the conclusion that export subsidies could be permitted in the GATT system as long as they are financed by producers themselves rather than being paid for by the taxpayer. The idea behind these Producer-Financed Export Subsidies (PFES) can be understood best by referring to Figure 7. As depicted, the PFES scheme applies to countries that, although they are natural importers, are currently exporting the commodity in question. As the domestic market price (P_d) is supported at a level far in excess of the world price (P_w), these exports ($Q_0 - C_0$) require export

Figure 7—Producer-financed export subsidies



subsidies equal to rectangle $abcd$ in value terms. To make producers pay for the export subsidy, an ad valorem tax of $(P_d/P_n) - 1$ is levied on them. As the tax reduces the net price received by producers from P_d to P_n , they will cut production from Q_0 to Q_1 . Consumers continue to pay price P_d , the official support price. (Note that PFES is at its heart also a two-price system, with a high price paid by consumers and a lower price received by farmers.) As a consequence of introducing PFES, the domestic surplus and, consequently, exports drop from $(Q_0 - C_0)$ to $(Q_1 - C_0)$. The amount of the required export subsidy falls from $abcd$ to $aehd$. The tax revenue collected from producers amounts to rectangle P_nfhP_d . In equilibrium, it just suffices to cover export subsidies.

Compared with a ban on export subsidies, PFES results in a rather small trade effect. Exports diminish only marginally with PFES, whereas they would completely cease for a natural importer if export subsidies were banned. Consequently, any effect on world export supply and world price is going to be small. (See Valdés and Zietz 1987 for some numerical calculations of the effect of PFES for the case of sugar.) For a given supply curve, the larger the price elasticity of domestic demand, the more favorable the trade effect of PFES.⁵⁰ PFES has absolutely no trade effect if domestic production is unresponsive to price changes, that is, when supply curve S in Figure 7 is vertical. In this case, PFES is simply borne by farmers without inducing a change in behavior. Disregarding this special case, the main advantage of PFES lies in the link it establishes between fluctuations in world market price and domestic production decisions, even if a system of variable levies is used to support the domestic market price at level P_d in Figure 7. This link has two positive trade effects. First, it moderates the effect on the volume of subsidized exports of both an increase in the domestic support price relative to the world price and an increase in productivity. Thereby it removes some of the uncertainty for nonsubsidizing exporters that is associated with government-financed, open-ended export subsidies. Second, PFES would diminish the adverse effect of a variable-levy system on world market instability.

The disadvantages of PFES can be summarized as follows. If implemented alone, PFES could never fully eliminate, only moderate, the possibility of subsidizing countries' raising their export volume. The EC's experience with a related system of producer levies demonstrates that subsidized exports could very well increase. (See Hubbard 1986 for a discussion of the coresponsibility levy as implemented in the EC.) It is important to point out in this context, however, that the EC's coresponsibility levies are not fully equivalent to PFES as illustrated in Figure 7. Not only are the levies not large enough to finance all export subsidies, but they are also established along with the domestic support price. Both differences operate to remove some vital functions of the PFES as intended, for example, by the Committee on Trade in Agriculture. Nevertheless, the EC's experience has shown that the introduction of the coresponsibility levies caused the farm lobby to exert great pressure on policymakers to also raise the domestic support price. This effectively kept the net price received by producers constant at its pretax level, thereby shifting the tax to consumers. (See Tangemann 1986 for a more detailed discussion and Tangemann 1984, 159-168.) Not surprisingly, consumption contracted further and the pressure to export increased rather than diminished.

PFES may also be objected to because it favors farmers of countries with a relatively small export share, for example, the EC as compared with Australasia. Having a small export share means that the tax per unit of production could be rather small, thereby causing little income loss to farmers and weakening the link between world market and domestic production

⁵⁰ In general, the larger the trade effect, the larger is the weighted sum of the elasticities of demand and supply.

decisions. A tax of negligible size also results in a small reduction in subsidized exports. Hence the trade effect of PFES would be small in countries with a large domestic consumption base and vice versa (see Hathaway 1987). For this reason, PFES may not be acceptable to nonsubsidizing exporters on equity grounds. However, the same reasoning, that is, the prospect of no fundamental change in trade flows, strongly favors PFES in terms of its political acceptability by the farm lobbies of populous countries such as the EC.

There is also a question of the extent to which PFES fits into the legal framework of the General Agreement. After all, PFES implies that the export price is below the price paid by domestic consumers. According to Article VI:1 of the General Agreement, this constitutes a case of dumping if the exports cause or threaten material injury to another country's producers. Hence, if one attaches some value to the legal consistency of the General Agreement, PFES does not appear worth further consideration. Rather than eliminating the special treatment of agricultural export subsidies, PFES would simply replace one special exception with another, although with one that is somewhat less objectionable from an economic standpoint.

In principle, PFES can moderate the negative trade effects on nonsubsidizing exporters of export subsidies by natural importers. In contrast to straight export subsidies, PFES is broadly consistent with the GATT's main principles as discussed in Chapter 4. It does not introduce discrimination among trading partners and, perhaps most important, it reactivates the price mechanism for protecting countries by forcing them, at least in theory, to vary the producer price in tandem with the world price. PFES, however, will not eliminate export competition from natural importers, nor will it turn them into actual importers. In other words, PFES in itself will not solve the problem of export subsidies. If a reversal of trade flows is desired, something has to be done to lower the level of domestic market price support from the prohibitive level that is at the root of export subsidies.

Containing Quantitative Import Restrictions

Minimum-Access Guarantees

As a complement to putting more disciplines on the behavior of agricultural exporters, either in the form of a ban on subsidized exports or by limiting them to PFES, import-protecting countries could also be made subject to firmer disciplines. Article VI:2(c) of the General Agreement currently gives countries the option to impose quotas on the importation of agricultural products to pursue certain domestic policy objectives (see Chapter 3 for more details). Import quotas are supposed to be accompanied by equivalent restraints on domestic production so that they will not result in a market share for imports that is lower than the one that could have been expected in the absence of import quotas. The idea of this provision is to safeguard traditional import shares and thereby ensure continued market access for exporters.⁵¹

The Committee on Trade in Agriculture has spent considerable time discussing ways to broaden this market-access provision of Article XI. Two ideas for an extension seem to have received the most support. The first would imply that the minimum-access rule of Article XI applies not only when a country imposes a quota but also when imports are restricted in any form other than through the bound tariffs written into a country's trade concessions. This would include, among other things, restrictions such as voluntary export restraints or a rise in the domestic support price. (Note that the minimum-access requirement would apply equally to

⁵¹Note that Article XI:2(c) does not guarantee the market share of a particular exporter—only that of all exporters. The provisions of Article XIII:2-4 on the nondiscriminatory administration of quantitative restrictions apply in this case.

all import-protecting countries regardless of whether they are currently importers or subsidizing exporters.) The second amendment of Article XI would require countries maintaining import restrictions other than bound tariffs to allow imports to reach a market share of at least X percent, regardless of the market share of imports in the recent past. This provision would add a new dimension to the minimum-access idea.

The minimum-access clause in its current form only safeguards a historical market share against rising levels of import protection or productivity changes over time, as discussed in Chapter 4. If the market share of imports happens to be close to or equal to zero because of historically very tight import restrictions,⁵² the minimum-access guarantee has no economic consequences. It cannot induce a change in policy. Adding an X percent provision to the current minimum-access rule would, by contrast, require a policy response by heavily protecting countries. It would force them to open up their protected markets at least to the extent that imports reach X percent.

The X percent rule could be implemented by defining minimum access either as a percentage of domestic consumption or as a percentage of domestic production. The former will have a greater trade effect, that is, will shift the world demand curve further to the right, if import-protecting countries are supporting their market price at below the self-sufficiency level and imports have not entirely ceased.⁵³ For countries that support the market price above this level and hence probably use export subsidies to dispose of their domestic surplus,⁵⁴ the trade effect will clearly be larger if minimum access is defined in terms of domestic production. It follows that, under the latter definition, the trade effect of the X percent rule increases whenever the support price is raised, whereas it would decrease if minimum-access requirements were expressed in terms of domestic consumption. Therefore, expressing the X percent rule in terms of domestic production is likely to provide a better disincentive to raising domestic support prices and hence protection. This definition will be assumed for the remainder of this section.

Four cases are analyzed to illustrate, in a comparative static framework, the trade effect of adding an X percent provision to the minimum-access rule currently in force. The four cases correspond to parts (a) to (d) of Figure 8. Figure 8(a) pictures domestic demand and supply curves for a commodity subject to a relatively low level of protection, as indicated by the percentage difference between domestic price P_d and world price P_w . Prior to minimum access, imports equal $C_0 - Q_0$. An X percent minimum-access requirement shifts the gross supply curve, that is, the horizontal sum of domestic production and minimum-access imports, from S to S_8 . At price P_d^0 , minimum-access imports equal distance ab , less than actual imports. Hence for case (a) the X percent provision has no trade effect. The world price remains unchanged.

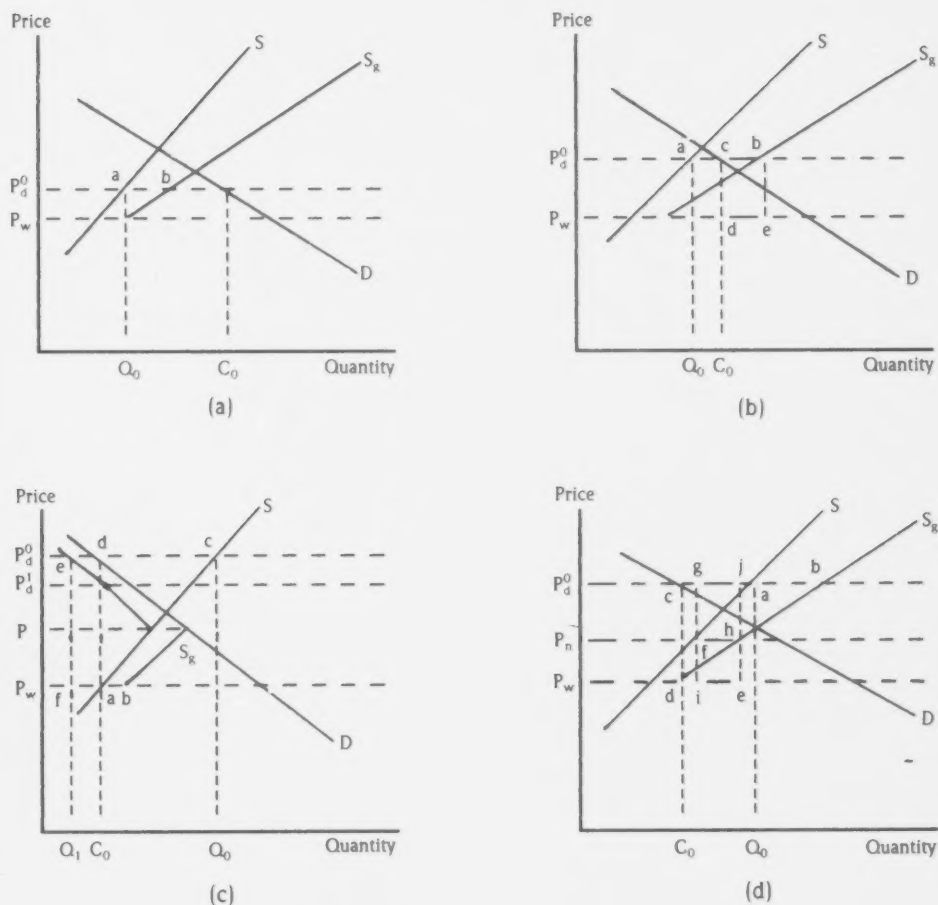
Figure 8(b) depicts a case where minimum-access imports at support price P_d^0 , distance ab , exceed actual imports at that price, $C_0 - Q_0$. Without a change in the support price, minimum-access imports turn the market from one characterized by excess demand into one characterized by excess supply. In order to identify the trade effects of an X percent provision in this case, some assumptions are required on the set of policies that would be allowed under a reformed GATT treaty and that are consistent with the country's domestic policy objectives. Regarding the latter, it will be assumed that continuous stock accumulation is out of the question, as is the destruction of excess supplies. Under these assumptions, the discussion of export subsidies in the previous section applies in full. If export subsidies are not banned, domestic surplus

⁵² Examples are the highly restrictive state trading practices Japan maintains for grains and the EC system of variable levies combined with export subsidies for wheat, beef, sugar, and other commodities.

⁵³ This description fits Japan for most agricultural products.

⁵⁴ The EC fits this description for a number of agricultural products, for example, beef.

Figure 8—Minimum-access guarantees under alternative economic conditions



bc could be exported, thereby avoiding any domestic adjustment and undoing any trade effect of the minimum-access imports. If protection is by tariffs or variable levies and minimum-access imports are not exempt, export subsidies could be fully financed out of tariff revenue. If import quotas or voluntary export restraints are used to raise the domestic price to P_d^0 , the reexport would require government funds equal to rectangle bcd .

If it is assumed that export subsidies are prohibited, expansionary demand or contractionary supply policies could be adopted to clear the market at price P_d^0 , that is, without a change in the level of protection. Either policy would cause minimum-access imports to have a positive effect on world demand, leading to an increase in world price. (In order to simplify the diagram, world price changes are not identified in Figure 8.) However, this applies only to the good in question. As explained in the section on export subsidies, it may well be that certain demand or supply policies have a negative trade impact on other goods, thereby partially canceling out the positive trade effect for the good examined. As an alternative to demand- or supply-

side policies, the level of protection could be reduced sufficiently to clear the market. Minimum-access imports would be lower as a result because of reduced domestic production, causing a somewhat lower trade effect compared with policies that act on domestic demand or supply. From a general equilibrium perspective, however, such a policy response would have the advantage of reducing negative trade repercussions on other goods.

Figure 8(c) demonstrates the trade effects that result when minimum-access import requirements of X percent are combined with a two-price system. The S_g curve identifying gross supply, the sum of domestic production and minimum imports, takes on a somewhat different shape in this case. For protection levels corresponding to prices below P_i , S_g is identical to the curves shown in the other parts of Figure 8. Deficiency payments are based on the domestic production forthcoming at those prices. Minimum-access imports are less than or equal to the difference between domestic demand and production. The situation resembles that depicted in Figure 8(a). For higher levels of protection, for which the sum of domestic production and minimum-access imports exceeds domestic consumption, a two-price system would limit deficiency payments to a quantity equal to domestic consumption minus minimum imports. The quantity receiving deficiency payments diminishes with rising protection levels. In the case depicted in Figure 8(c), production reaches a maximum at domestic support price P_i . It falls for higher levels of the support price and reaches a minimum at price $P_d^{1/55}$. This implies that minimum imports will never be smaller than indicated by distance ab . For domestic support prices between P_w and P_d^1 , minimum-access imports will be larger than ab , and for support prices above P_d^1 , minimum imports will be exactly equal to distance ab ($=ed$).

To analyze the trade effects of superimposing an X percent provision on a two-price system, it is convenient to start with a protection level corresponding to price P_d^0 . If a two-price system is in effect, the domestic market just clears at that price. Both production and consumption are at level C_0 and deficiency payments amount to area acd . Minimum-access import requirements of size ab ($=ed$) have a different trade effect depending on how the government reacts. Let us assume that pure demand- or supply-side policies, as discussed in the section on export subsidies, are considered infeasible. (If they are feasible, there is no reason to introduce a two-price system in the first place.) In this case, the government has to reduce the subsidized quota assigned to domestic farmers from C_0 to Q_1 if the domestic support price is kept constant. If deficiency payments are raised sufficiently, that is, by amount $fade$, farmers will be as well off as before minimum-access imports if they export quantity $C_0 - Q_1$. As exports happen to be exactly equal to minimum imports, world price will not change as a result of minimum access.

There is no positive trade effect of minimum access; all it does is raise the domestic tax burden. Farmers will be better off, however, if they can sell quantity $C_0 - Q_1$ in the domestic market rather than in the world market. (The government may not be able to prevent this from happening because the commodity does not pass through an easily controllable processing or marketing channel.) In this case the domestic price will drop to P_d^1 and minimum-access imports will have a positive trade effect. In short, superimposing minimum access on a two-price system can guarantee a positive trade effect only if there is a rule that prohibits importing countries from reexporting minimum-access imports or exporting an equivalent amount of domestic production. Without such a rule, minimum access may have a positive trade effect but it is not certain.

⁵⁵ For a production quota below C_0 , which corresponds to a support price above P_d^1 , farmers could compete in the world markets. Hence they have a strong incentive to produce at least C_0 , that is, in excess of their production quota. As it is more profitable for them to sell in the domestic market than to export, the domestic price will fall to P_d^1 . See the discussion of deficiency payments earlier in this chapter.

Finally, Figure 8(d) illustrates the trade effects if an X percent minimum-access provision is combined with PFES. At price P_0^0 and prior to PFES and minimum imports, subsidized exports equal distance $Q_0 - C_0$. Without a change in support price, minimum-access imports of size ab would add to the existing surplus (ca). Introducing PFES would imply a levy on domestic production of size $(P_0^0 - P_n)$, so that revenue from this levy, rectangle $P_n fg P_0^0$, just equals export restitutions, area $jcde$. At the production level corresponding to the net price received by farmers (P_n), minimum-access imports are equal to distance fh , whereas total subsidized exports correspond to $de (=cj)$, implying that all required imports are reexported. Distance cg represents the part of subsidized exports that is not due to minimum-access imports.

Although minimum-access imports are reexported in full, they do have a positive trade effect when combined with PFES. This results from both the shift to the right of world import demand due to minimum-access imports and the shift to the left of world export supply. Note in this connection that subsidized exports are not simply rising by the amount of minimum-access imports, thereby canceling out any effect of minimum imports on world price. On the contrary, exports are falling, from ac to jc . This is due to a sizable decline in domestic production (ag) compared with the situation prior to PFES and minimum access. As a result of the production decline, the "homemade" surplus has shrunk to cg . If PFES were implemented alone, without being combined with minimum access, this homemade surplus would clearly be larger than cg , because the revenue of the producer tax depicted in Figure 8(d), area $P_n fg P_0^0$, would greatly exceed export subsidy requirements in the absence of minimum access, area $icgd$. A larger homemade surplus, however, would imply, *ceteris paribus*, a smaller shift to the left of the world export supply curve, and hence less of a positive trade effect. Finally, it should be noted that adding minimum access to PFES will have an increasingly smaller effect on world price the less elastic domestic production reacts to price. In the section on PFES it was noted that a completely inelastic domestic supply schedule deprives PFES of any trade effect. Adding minimum access to PFES will not change this result.

To sum up, if an X percent minimum-access provision were introduced without combining it with restraint on export subsidies, either in the form of a complete ban or limiting them to PFES, it would be unlikely to have any appreciable positive trade effect. The introduction of or an increase in subsidized exports, either in explicit or implicit form, would be a natural avoidance strategy for import-protecting countries. Whether this is also affordable for a country depends largely on budgetary considerations. For countries with sufficient budgetary resources, no adjustment can be expected. For others, some reduction in the protection level and hence some positive trade effect could come forth. Basically, the choice for countries would be qualitatively the same as the one faced by any import-protecting country without minimum-access import obligations. Minimum-access imports just make the budgetary pressure more pronounced. But, clearly, they do not force upon a protecting country a particular internal response pattern. In particular, minimum-access imports do not manage by themselves to establish a link between domestic price and world price.

Without a ban on export subsidies, an X percent minimum-access provision can at most guarantee a quota rent for the exporter to the protected market. For the case depicted in Figure 8(b) the rent would amount to rectangle $bcde$, and for the case of Figure 8(d), to area $eigi$. These rents, however, materialize in full only if quota imports are tariff-free. (Should traders in the importing country receive licenses for the amount of the quota imports, possibly as a result of a competitive bidding process, the quota rent, after subtraction of any tariff, would be reaped by importers rather than by exporting countries.) Should imports be subject to tariffs, then the quota rent is reduced accordingly by the tariff. Minimum-access rights would not give those countries that happen to fill the minimum import quota an increase in overall export quantity. Rather, their exports to the minimum-access countries would be just matched by an export decline in third-country markets that are not subject to minimum access. This oc-

curs because the countries subject to minimum-access imports are likely to increase subsidized exports to these same third-country markets.

If export subsidies are prohibited, an X percent minimum-access provision can be expected to generate a one-time positive trade effect, as import-protecting countries that are self-sufficient or close to it are forced to import minimum-access quantities. Over time, as production increased relative to demand, minimum-access imports would force the import-protecting country to lower the domestic support price to balance demand and supply. (This is true regardless of whether minimum access is defined in terms of production, as recommended, or in terms of consumption, as in Article XI:2(c).) Although the domestic price adjustment is a desirable result, the simultaneous freezing of import quantities or shares that would result is not. It effectively blocks the forces of comparative advantage from operating and hence contradicts the very spirit of the General Agreement.

An advantage of minimum-access import requirements is the relative ease with which they can be monitored. This is independent of the type of protection system used and applies to both the minimum-access rule of Article XI:2 and the suggested X percent minimum-import provision. Quantifying minimum access is hardly a problem for the minimum-access rule of Article XI. All that is required is a decision on the base period on which the market share reserved for imports is based. Quantifying the X percent rule, however, is far less straightforward. Should minimum-access imports amount to at least 10 percent of domestic production for a natural importer? Should that figure be the same for all commodities? These are difficult questions that would have to be resolved in the process of negotiation.

The minimum-access guarantee of Article XI is specific to agriculture. Restricting agricultural trade reform to tightening Article XI by adding an X percent provision and, possibly, a ban on export subsidies, would mean continuing to treat agriculture as a special case with its own rules of behavior. Treating agriculture as a special case in the GATT negotiations, though, has a number of distinct disadvantages from a political-economy perspective. (These were detailed in Chapter 4.) However, there is nothing about minimum access that makes it specific to agriculture on *a priori* grounds. A minimum-access rule like the one laid down in Article XI and amended by an X percent provision could very well apply to all trade, regardless of sector. If minimum access is interpreted in this more general form, it could be employed to condition the use of any type of trade-restricting measure apart from bound tariffs. This idea will be taken up again in Chapter 6, where it is incorporated as part of a trade reform proposal.

Tariffication or Global Quotas

Bound tariffs are the principal exception to free trade envisioned by the GATT. The reason is that they preserve the main principles of the GATT, such as reliance on the price mechanism and nondiscrimination, as no other trade restriction can. In agriculture, however, nontariff barriers to trade play a more important role than tariffs, thereby excepting the sector from central GATT principles. Tariffication is a reform proposal that is intended to reverse this. Among economists this idea has a wide following.⁵⁶

Tariffication has two objectives, one for the long run and the other for the short run. Its long-run objective is to replace all nontariff barriers and unbound tariffs with low bound tariffs. To minimize distortions of resource allocation, it is widely recognized that these bound tariffs should be uniform for broad commodity groups. In the short run, tariffication implies that the existing nontariff barriers would be converted into their respective tariff equivalents. This would clearly mean that, for many agricultural products and countries, the resulting tariff

⁵⁶ Advocates of this approach include, for example, Koester (1987), Patterson and Patterson (1986), and the cosigners of Institute for International Economics and The Institute for Research on Public Policy (1988).

equivalents would be far in excess of the bound tariff rates that may exist currently or that are envisioned to apply after the adjustment to a tariffs-only world has been completed.

In some form or other, then, countries have to be released temporarily from the obligations associated with bound tariffs. In order to avoid a permanent increase in tariff rates, however, the duration of this exception would have to be strictly limited. Preferably, a schedule of mandatory tariff reductions, from the tariff equivalent down to the existing bound tariff rate, should be attached to a temporary waiver on the tariff concessions. To reduce the possibility of prohibitive tariffs during this adjustment period, countries could be obligated to abide by the minimum-access rule of Article XI:2; that is, importers would be required to preserve the historical market share of imports during the transition phase.

The trade effects of tariffication can be analyzed conveniently if it is pitted against a potential alternative trade reform, the conversion of all nontariff barriers into a global quota rather than tariffs (see Hufbauer and Schott 1985 for a discussion of this alternative). Gradual liberalization would then proceed in the form of increasingly larger quotas over time. Global quotas have features similar to those of tariffs. They are nondiscriminatory, easy to administer and monitor, and address only the problem of frontier barriers. A major difference lies in the fact that global quotas do not establish a link between domestic and world prices at a given quota level. Not only does this mean that an important GATT principle is violated, but it also has certain consequences for the development of trade.

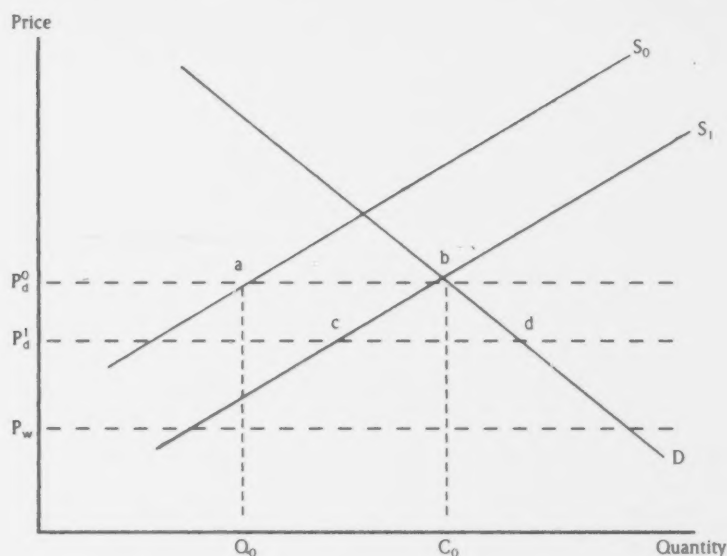
In the short run and for a given world price, replacing nontariff barriers with tariffs of the same restrictive effect changes neither domestic price nor the overall level of trade. However, the composition of imports, assuming the tariff equivalent is not prohibitive, may change if some of the nontariff barriers formerly discriminated trade by origin. A global quota would not differ from tariffication in this short-run respect. This ceases to be true if the assumption of a constant world price is relaxed. A lower (higher) world price increases (lowers) imports in the case of tariffs, but has no trade impact in a world of quotas. The trade effect resulting from tariffication moderates world price changes. Hence world price fluctuations should decline under such a system.

Over time, as domestic demand and supply curves shift, a constant tariff equivalent also has different consequences from a fixed quota. Take first the case that is usually quoted in this context: demand growth exceeds domestic production growth. A fixed import quota implies no growth in imports but rather an increase in the level of protection. For a bound tariff, in contrast, imports increase by the full amount of excess demand growth. Hence tariffs ensure a positive trade effect; quotas do not, unless the quotas are made adjustable upward, possibly through some automatic escalator system triggered on demand growth.

Take now the reverse case of production growth outstripping demand growth. For a constant tariff, imports decline; for a fixed import quota, this is not the case as long as export subsidies are prohibited and the domestic support price is above the world market price. The global quota will have an effect equivalent to minimum-access import guarantees under these conditions. This point is illustrated in Figure 9.

Before the domestic supply curve shifts to the right from S_0 to S_1 , an ad valorem tariff of $(P_d^0/P_w) - 1$ percent and an import quota of size ab both establish a domestic price of P_d^0 , with imports being equal to $C_0 - Q_0$. After the shift of the supply curve to S_1 , imports cease under the tariff arrangement, whereas they remain constant for the case of the quota. If export subsidies are prohibited, the domestic price level declines from P_d^0 to P_d^1 under the quota arrangement ($cd = ab$), whereas it stays constant under the tariff regime. The price decline under the quota arrangement clearly assumes that the government follows a market-oriented policy. As was discussed at length in the section on export subsidies, any number of alternative reaction patterns is possible, from pure demand-stimulating policies to two-price systems. Any of these policies could avoid or moderate the decline in the domestic support price. In short, there

Figure 9—Tariffs and global quotas with domestic production growth



is nothing automatic about the price decline under the quota arrangement and the ban on export subsidies.

If export subsidies are not prohibited, then a country under the quota regime could choose to export quantity cd with the help of export subsidies rather than allow the support price to fall from P_d^0 to P_d^1 . Although gross imports would not diminish in this case, as they would under the tariff arrangement, net imports would be zero, just as in the tariff case. From the perspective of nonsubsidizing exporters, then, there is little difference between the quota or tariff regime if export subsidies are allowed.⁵⁷ The world price would tend to drop in either case.

Tariffication gives rise to another concern that is absent in the case of a global quota. Countries may resort to gray-area measures such as voluntary export restraints or orderly marketing agreements. This is not a development one would expect immediately, as tariffs are set at their nontariff barrier equivalent, but only over time, as these high tariff rates are lowered to their bound levels. This concern is not unfounded on an a priori basis, given the historical experience with tariff reductions in many segments of manufactures.

In numerous industries, tariff cuts negotiated in previous multilateral trade negotiations were subsequently reversed, at least partially, through the introduction of such gray-area measures. As new low-cost suppliers enter the market on a broader basis, this tendency seems to gain increasing momentum, spreading across more and more industries. In agriculture, however, this threat is probably of less concern for at least two reasons. First, new low-cost suppliers, such as the newly industrialized countries in industrial goods, are not as easily created in agriculture as in industry. Availability of fertile land and appropriate climate are strong constraining factors. Few if any new competitors can be expected to appear on agricultural markets, although some traditional ones, particularly in Latin America, still have considerable

⁵⁷ The case of a potential quota rent is disregarded here for simplicity.

growth potential. Second, voluntary export restraints and orderly marketing agreements are largely levied against developing countries, especially the newly industrialized countries. Compared with the major suppliers in agriculture, such as the United States, Canada, and Australasia, they have little political or economic clout to withstand trade restrictions.

Some comments are needed on the political-economy implications of tariffication versus global quotas. Quotas seem to be preferred over tariffication among farmers. The trade effect of quotas is considered more predictable because, unlike that of tariffs, it is not subject to the vagaries of estimating demand and supply functions. It is also independent of changes in relative costs. Predictable or unforeseen changes in comparative advantage, in other words, have no bearing on trade flows. Furthermore, high tariff levels for agriculture would be difficult to explain to voters as well as to industries not subject to similarly high protection levels. Quotas are not standardized in the way tariffs are and are thus harder to pin down in their restrictive effect for the uninitiated observer.

A system of global declining quotas also has a definite disadvantage from a political-economy point of view. It is generally agreed that zero tariffs or quotas at the free-trade level are unrealistic for the foreseeable future. Hence, the end point of the process of tariffication would be realistically the establishment of a system of relatively low bound tariffs, not free trade. In terms of global quotas this would translate into quotas close to, but not equivalent to, the free-trade level. As demand and supply change over time, no government decision is required under the tariff system. The level of protection remains the same. Under a quota system, changes in demand and supply would require constant adjustments of the quota to keep its protective effect constant. This naturally gives rise to continual conflicts with the affected producers. It deprives governments of the protective shield against the demands of special interest groups for protection that is characteristic of a tariff. A tariff automates domestic price decision by linking the domestic price to the world price; a quota arrangement does not.

Binding the Level of Protection

Choices in Defining the Level of Protection

An alternative to restricting the use of specific instruments with a direct trade impact is to bind the level of protection, defined either separately for each commodity or jointly, that is, commodity-independent, for the country as a whole. Such a scheme would allow each country to decide on its own what trade-inhibiting measures to apply, as long as the level of protection stayed below a certain threshold as written into the country's GATT concessions. This threshold-protection level could be determined either by reference to a particular year or average of past years or by free negotiation among the GATT signatories. At any rate, once agreed upon, it could be bound in exactly the same way as a tariff.

Such an approach is not all that new. Something rather similar was put on the negotiating table once before during multilateral trade negotiations. During the Kennedy Round the EC made such a suggestion in the form of the *moutant de soutien* or "margin of support" strategy. The proposal was rejected by the United States at that time because it did not contain minimum-access guarantees to the EC market and endangered U.S. market access to the EC for products covered by bound tariffs. At present, there is again intense interest in the binding of protection levels as a way to halt the growth of protectionism in agriculture. The choice seems to boil down to one of the following three methods of measurement: nominal rates of protection (NRP), effective rates of protection (ERP), and the overall level of protection as measured by

Producer Subsidy Equivalent (PSE) or any of its derivatives, such as Trade Distortion Equivalent (TDE).⁵⁸

The NRP is widely used in empirical analysis. Its popularity stems in part from its relative simplicity and the intuitive sense it makes. As the NRP is based on a comparison of domestic and world market prices, the data requirements are rather limited. All that is needed is information on two prices for each commodity. Despite its simplicity, the NRP measure has the advantage that it captures the most important protectionist measures quite adequately, making avoidance strategies on the part of protecting countries more difficult. The reason is that common protectionist measures, such as variable levies, tariffs, quotas, and the protectionist activities of state trading enterprises, directly affect the price differential between domestic and world market prices. Increases in the level of protection through these trade policy instruments generally show up in a greater differential between world price and domestic price.

However, there are some well-known cases for which the incentive effect of protection to producers, and hence the ultimate trade effect, is not fully captured by the NRP. One such case occurs when the inputs used in the production process are subject to levels of protection that are very different from those on the final product. In this case, the NRP on the final product underestimates the incentive effect to producers and, hence, the trade effect. The ERP is meant to correct for this shortcoming. It takes into account differences in the level of protection among inputs and final product.

Although the ERP better captures the true level of protection accorded to an economic activity, this measure also has its shortcomings. First and foremost, its calculation is far from easy. It requires a considerable amount of detailed information about input-output relationships—information that is simply not available in many cases. This is reflected in the limited number of empirical studies utilizing this measure for more than a few select products. Furthermore, it is unlikely that imported inputs play a large role for the majority of primary agricultural products that are being traded.⁵⁹ Finally, the ERP has one serious flaw in its use as a measurement concept that is of particular importance for heavily protected agricultural products, that is, the ERP is difficult or impossible to interpret when free-trade value added is low or negative. The ERP measure will assume very large positive or negative values under these circumstances, thereby rendering it ineffective for measurement purposes.

The NRP measure is a poor guide to the trade effects of government policies in a number of other instances apart from the case of differential rates of protection on inputs and final products. Examples are deficiency payments, input or production subsidies, and voluntary export restraints with the quota managed by the exporter.⁶⁰ In these cases the NRP may fail to establish a unique link between measured price difference or the lack thereof and the measure's trade impact. This has been illustrated for the case of deficiency payments in connection with Figures 5 and 6. If farmers receive deficiency payments only for the quantity they would produce in the absence of import barriers, these payments have no negative trade effect. This applies equally in the case where the country is an importer at the given world price and where it is an exporter. Hence an NRP of zero would correctly indicate the absence of negative trade effects, assuming consumers can buy at the world price. Deficiency payments beyond the

⁵⁸ TDE is equivalent to PSE except that it intends to capture only government support measures that are explicitly trade-distorting. The Canadian proposal for agricultural trade reform at the Geneva talks is based on this measure.

⁵⁹ This is not to say that there are no cases in agriculture where the ERP is likely to be significantly above the NRP. One example would be the protection of the meat industry in the EC. Its NRP is high, but the low tariffs on feed imports, such as soybeans and citrus pulp, make its ERP even higher.

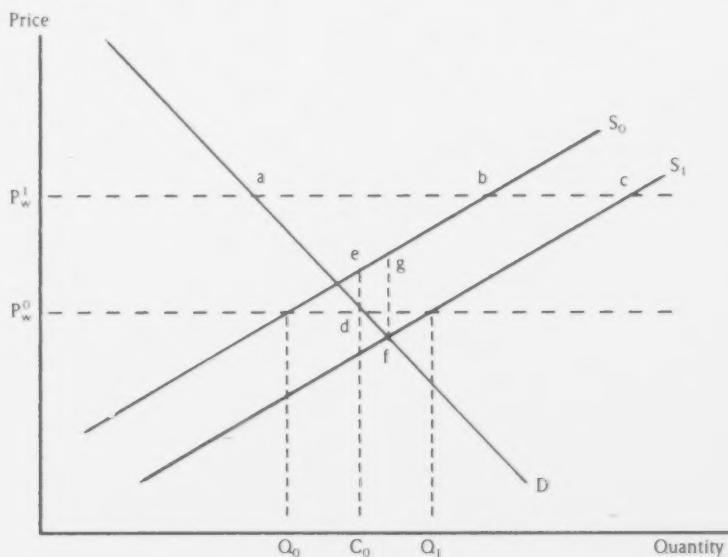
⁶⁰ The NRP will be affected by the voluntary export restraint only if a price other than the import price is used as a proxy for the world price for the purpose of comparison with the domestic price. A very similar argument holds for health and other standards that imports have to conform to.

quantities that would be produced in the absence of protection, however, do affect trade by either reducing imports or increasing exports. The NRP measure fails to show a negative trade effect in this case.

The NRP measure is even less useful in handling production subsidies than deficiency payments. It will never be able to identify the trade-distorting effects of subsidies. This is illustrated in Figure 10 for two alternative levels of the world price. To focus on the subsidy effect, the world price is assumed to be equal to the prevailing domestic price in each case. Before the introduction of production subsidies, the country is a net importer of quantity $C_1 - Q_0$ at the lower world price (P_w^0) and a net exporter of quantity ab at the higher world price. A per-unit production subsidy of sufficient size, that is, in excess of distance de , will make the country a net exporter even at price P_w^0 . The subsidy identified by fg , for example, induces exports of size $Q_1 - C_0$. At price level P_w^0 , a subsidy of this same size raises exports from ab to level ac . In neither case, however, is there a change in the NRP measure, yet negative trade effects certainly exist.

The latter two cases, that is, deficiency payments and domestic subsidies,⁶¹ are typical examples of the rationale for extending the NRP measure into PSE. The overall level of protection as measured by PSE is a refinement or extension of the NRP measure in the sense that per-unit transfers received by farmers are added to the NRP measure if their effect on production is not already captured by the NRP.⁶² Unlike the ERP, PSE does not rely on in-depth knowledge

Figure 10—Trade impact of domestic subsidies at different levels of world price



⁶¹ Denaturing premiums that are paid to convert a surplus product into a product for which the domestic surplus is less acute can also be considered production subsidies, although not for the denatured product (for example, wine), but for the end product (for example, industrial alcohol).

⁶² The idea of PSE originates with Josling, as developed in FAO 1975. In-depth discussions and practical applications can be found in Organisation for Economic Co-operation and Development 1987; Tangermann, Josling, and Pearson 1987; and U.S. Department of Agriculture 1987.

of technical input-output relationships. The measure is similar to the NRP in that the problems addressed by the ERP are not explicitly considered.⁶³ PSE's major advantage over the NRP is its more comprehensive coverage of governmental policies. PSE captures policies, such as subsidies, that have a potentially negative trade effect, yet do not change the differential between world price and domestic price and hence the NRP.

Evaluating the Usefulness of Bound Protection Levels

Binding the protection level, whether in terms of the NRP or PSE, is fully consistent with the GATT's emphasis on the price mechanism. However, only if the protection level is defined in terms of PSE will world price fluctuations feed through to producers, either as changes in price or as transfers. This applies regardless of the intervention scheme that is applied by the government if PSE is defined in a very comprehensive manner. But given such a definition, PSE can dramatically reduce the possibilities open to governments to avoid the consequences of bound or reduced protection levels. For example, the substitution of domestic subsidies for export subsidies would be clearly impossible. PSE's advantage over the NRP lies in its ability to add up measures with direct and indirect trade effects in a consistent manner. This makes it appealing to anyone who thinks that the GATT's emphasis on measures with direct trade effect, that is, frontier barriers to trade, is in need of revision. PSE is flexible enough to allow the inclusion of only those government market interventions that have an actual or potential negative trade effect. As subsidies are constrained by PSE, both productivity increases and their expansionary effect on domestic supply or exports are curtailed. In that sense, PSE seems rather resilient to the trend in supply growth, whereas the NRP lacks that characteristic.

PSE also has a number of drawbacks. Probably its most serious disadvantage, one that it shares with the NRP, is that it keeps the door wide open for protecting countries to discriminate among trading partners. For example, nothing stands in the way of protectionist countries' continuing or switching to a system based on voluntary export restraints, discriminatory quotas, or selective tariffs. How this element of trade discrimination could be handled in a world of bound levels of protection is an open question. What is clear, however, is that the GATT principle of nondiscrimination is not enforced automatically through any such scheme. The only way nondiscrimination could be effected if overall protection levels were bound would be through some ancillary arrangement, such as increasing the monitoring capability of the GATT or some other organization, and possibly providing for the option to intervene when a case of trade discrimination becomes apparent.

Discrimination could be a particularly serious problem if the overall protection level is bound—not for each commodity individually, but for a group of commodities or for all agricultural commodities traded by a country. Under such a scheme, each country would be able to decide on its own how to allocate its protection allowance among individual products (such a possibility is suggested in Tangermann, Josling, and Pearson 1987). It would allow countries to extend protection for those commodities they consider most important for their farmers and resort to free trade for less important products. This flexibility probably has more negative consequences than positive ones. It would give politicians great latitude in supporting markets at levels far removed from levels consistent with comparative advantage. World markets could end up severely distorted for certain products on which a large share of the protection allowance is concentrated. This could be devastating for nonsubsidizing exporters

⁶³ Conceptually, however, it appears feasible to modify PSE to incorporate the information content of ERP. It would be necessary to calculate the value of the per-unit tariff concessions, relative to the product being analyzed, for those inputs that are subject to lower protection levels and add them to the NRP or other government outlays affecting the product.

that rely on these products but do not also trade in other products for which protection has declined at the same time.

Further, nonuniform protection could worsen existing negative trade effects or create new ones through its impact on the ERP. In short, the possibilities of negative trade effects through uninhibited trade discrimination are staggering. As always, discrimination and selectivity are going to hurt most those countries with less political or economic clout. In all likelihood, these will be developing countries. This makes PSE a questionable choice as the main theme of trade reform in agriculture, particularly if it is not intended to apply to each commodity separately but to groups of commodities on average.

A related disadvantage of fixing the overall protection level, in the form of the NRP or PSE, is the difficulty of exactly pinning down the resulting trade effect. Some examples may illustrate this point. Take the case of subsidies as pictured in Figure 10, a case that seems to be predestined for the application of PSE. Yet it is easy to see that a production subsidy of size de per unit does not have the same effect on trade at price P_w^0 as would raising the protection level and support price by the same amount. In the former case imports cease, whereas in the latter case not only do imports cease but subsidized exports are forthcoming, making for a much worse trade effect. Deficiency payments pose another serious problem for the NRP or PSE. Figure 5 can illustrate this. As per-unit payments of size $(P_i - P_j)$ are not incorporated in the measurement of the NRP, because they have no additional trade effect, the NRP, as calculated from P_i and P_w , would be the relevant measure of protection. Yet the NRP, if applied to domestic demand and supply curves, would predict exports of size dc , although they have ceased altogether. Hence the NRP measure would vastly overestimate the negative trade effect of a two-price system as pictured in Figure 5.

The above cases can equally well serve to demonstrate that the binding of protection levels, by the NRP or PSE, would allow a country to change over from a protection scheme with minimal negative trade effect (for example, a two-price system) to one with maximum negative trade effect (for example, a variable levy cum export subsidy system).⁶⁴ This example, although somewhat extreme, nevertheless reveals an inherent weakness of the binding of protection levels.

A number of measurement problems further weaken the case for the NRP or PSE as a basis for trade reform. One facet of this problem is the issue of quality differences. They are reflected in price differences the same way as protective measures. This is an important point for highly differentiated products, for which competition is at least to some extent based on quality. Beef, for example, is such a product. The problem of quality differences is of less importance for standardized products, such as refined sugar.

Another measurement problem—applicable only to PSE, not the NRP—relates to the identification of all subsidy expenditures on farm programs. It should come as no surprise that subsidy levels as reported by governments generally underestimate the true ex post levels.⁶⁵ Incomplete reporting, hiding of funds in other budget items, special mid-budget-year appropriations, and disbursements of funds from even less-clear budgets at other than the highest government level help to confuse the true magnitude of government support. The funds expended to support agriculture in the EC, for example, come only partially from the EC budget, although most international comparisons are based only on those figures. Disbursements by

⁶⁴ Note that export restitutions are not added to the NRP measure because this would involve double counting. The trade effect of a variable levy cum export subsidy scheme is fully captured by the simple NRP.

⁶⁵ It is not uncommon to find independent investigators uncovering levels of subsidization far in excess of those officially published. See, for example, Jüttemeier 1987 for details on the West German case.

national governments, however, probably double the true amount of financial support to the farming sector in the EC.

Finally, as the work of the OECD on PSE amply demonstrates (Organisation for Economic Co-operation and Development 1987), governments manage to complicate certain intervention schemes over time so that reliable estimates of their effects become extremely difficult. This is mainly because the initial interventions lead to unexpected results, such as steep unsustainable increases in program costs. As a reaction to budgetary pressures, "quick fixes" are added in an unsystematic manner, making the whole system ever more bureaucratic, less efficient, and harder to comprehend.

A further measurement problem relating to the fixing of overall protection levels derives from the strong dependence of the NRP and PSE on levels of exchange rates. Although exchange-rate fluctuations also affect other reform ideas, they are by far the most important for measures of overall protection that rely on price comparisons. (The exchange-rate issue is taken up again in Chapter 6.) Recent experience has shown that exchange rates can vary rather dramatically and over short periods of time. A depreciating dollar, for example, can increase the NRP both for goods quoted in dollar prices and for countries outside the dollar zone without there being a change in agricultural markets, import protection, or world prices. The reverse case, an appreciating dollar, would allow countries outside the dollar zone to raise domestic prices, and hence to upset trade relations, without violating the bound NRP. These problems are obviously serious, but how to handle them in actual measurement practice is far from clear. Simple three-year averages of exchange rates or similar schemes can dampen fluctuations; they do not eliminate the problem.

Bound overall protection levels would also cause problems for agricultural policy in times of wild fluctuations in world price. Averaging would again lessen the need for sharp policy adjustments. Yet major problems remain if world prices move in an unexpected direction at the end of a period whose average is compared with the bound level of protection. It has been suggested (Tangermann, Josling, and Pearson 1987) that countries be mandated to use price forecasts prepared by the GATT for guiding domestic policy, especially in the crucial last year or years of a measurement period.

Similar procedures are employed in connection with the compensatory financing facility of the International Monetary Fund (IMF) for export revenues of developing countries. It is unlikely, though, that the analogy is close enough to be meaningful. The crucial difference between the IMF's scheme and the one suggested above is the number and size of countries acting on the same price forecasts. For example, if the EC and the United States—both major players on the world market for numerous commodities—act on a given set of price forecasts, these forecasts are certain to turn out wrong *ex post*. They will be self-defeating. The situation is qualitatively different if a small developing country with moderate or no influence on the world price is involved, as is common for the IMF's compensatory financing scheme. Above all, however, the compensatory financing scheme does not require adjustments in policy to counteract the price forecasts, as would be the case if it were used to make countries abide by their pledges to bind their protection levels.

Based on political-economy considerations, the adoption of the NRP or PSE measures of overall protection are ambiguous at best. The main advantage of binding the protection level at this stage seems to be the stated unwillingness of the EC to link the trade talks with a discussion of reform of its internal agricultural policy regime. But as export subsidies, variable levies, or other trade-distorting measures are an integral part of domestic policies of farm support, any negotiating strategy that focuses on the removal of these measures could run into difficult problems at the negotiations.

The NRP or PSE, in contrast, would provide maneuvering room for governments, allowing them to choose those protective measures that are politically the most acceptable, within the

obligations imposed by the NRP or PSE. But the considerable amount of discretion provided by the NRP and PSE also happens to be a potential problem: it subjects the government to constant pressure from the farm lobby. Finally, PSE or even the NRP cannot be seriously considered as a theme for the Uruguay Round in general. The problems of quality differences are too major for much of manufacturing to be ignored. As a result, adopting the NRP or PSE in agriculture, but going an entirely different route in manufacturing, would establish agriculture officially as a special case, with all the attendant problems outlined in detail in Chapter 4.

In sum, both the NRP and the PSE or any of its derivatives seem unsuitable as a basis for legal commitments by the GATT contracting parties. Binding the overall protection level cannot serve as the sought-after unifying theme of the Uruguay Round. However, this does not mean that PSE is useless for the GATT negotiations. Even if it should not be incorporated in any form into the General Agreement, PSE or any of its derivatives can serve a useful function as a measuring device during the negotiations to facilitate compromises and to set targets for liberalization, or as a monitoring device thereafter to check on the progress of trade liberalization over time.

OUTLINE OF A TRADE REFORM PACKAGE

The Basic Elements of the Reform Proposal and Its Rationale

The objective of multilateral trade negotiations under the aegis of the GATT has been and will continue to be the elimination of frontier barriers to trade, in agriculture as well as in other areas. Although political conditions make achieving this long-run objective highly unlikely in the short run or probably even in the medium run, it is important not to lose sight of it. Any idea for trade reform should, at a minimum, provide a smooth transition to this objective rather than obstruct its eventual achievement. The most important criteria by which to judge whether a reform proposal fits into this category were set out at the beginning of this study and have been applied subsequently in the evaluation of numerous ideas for trade reform. It is apparent from this analysis that all the criteria that have been established could probably not be satisfied by a single idea or element of trade reform. But an appropriate combination of reform ideas may achieve this end; the one favored by the authors would consist of a strict ban on export subsidies combined with comprehensive tariffication.

The ban on export subsidies would eliminate the special treatment for agricultural, fishery, and forestry products in the General Agreement and the Subsidies Code. All goods would be subject to the same disciplines on export subsidies. In terms of the GATT code this implies the elimination of Article XVI:3 from the General Agreement and Article 10 from the Subsidies Code. The remainder of Article XVI of the General Agreement and Article 9 of the Subsidies Code would be changed to cover all products, regardless of sectoral origin. The Annex to the Subsidies Code (see Appendix 2) could also be amended to include some more pertinent examples of export subsidies that are specific to agriculture.⁶⁶ In this way, certain cases of indirect export subsidization that were mentioned in the context of deficiency payments schemes in Chapter 5 could be captured. As was concluded there, indirect export subsidies by countries that would be importers in the absence of import protection are easily identified by the existence of net exports despite positive rates of protection. Identifying indirect export subsidies for a competitive exporter that maintains no import restrictions was considered less clear-cut theoretically, although still possible if a pragmatic attitude is maintained. A simple solution would be to disallow deficiency payments on output levels in excess of domestic consumption. This would eliminate, among other things, the export subsidy problem associated with the current U.S. practice of disbursing deficiency payments on all domestic production, subject only to participation in acreage reduction programs.

Tariffication, the second element of the suggested trade reform package, consists of (1) replacing all unbound tariffs and nontariff barriers, such as variable levies, quotas, and voluntary export restraints, with bound base tariffs that are uniform across broad commodity groups for each country,⁶⁷ and (2) extending the tariffication idea to the safeguard Article XIX. The bound base tariff of part (1) is a country's basic tariff concession. It is the tariff level that would be applied

⁶⁶ Note in this context that numerous subsidy practices now common in agriculture would be clear violations of the Subsidies Code and its Annex even without its amendment. An example is the transportation subsidies granted to Canadian grain destined for export (see Organisation for Economic Co-operation and Development 1987, 282).

⁶⁷ Tariffs should certainly be uniform across commodities with significant cross-price elasticities; for example, grains and grain substitutes. Tropical products is another example.

uniformly across broad commodity groups by a given country after completion of the adjustment to a system based only on tariffs. Unless it invokes Article XIX, a country is bound to this tariff. Unbinding the tariff entails, as currently stipulated in the General Agreement, paying compensation to the affected trading partners or facing retaliation. The base tariff is, quite naturally, also the subject of subsequent multilateral trade negotiations on tariff reductions.

As it is probably politically impossible to shift from the current system of almost universal nontariff protection in agriculture to one of bound tariffs, and that at a relatively low uniform level, any agreement on tariffication will have to contain provisions for temporary import relief for the time period needed to restructure the industry or, at least, domestic support programs. Part (2) of the tariffication idea addresses this need. Once the adjustment period is over and a system of bound tariffs has been established, its major use would be to condition the response of importers to import surges according to Article XIX.

Extending tariffication to Article XIX implies that safeguard measures are limited to temporary tariff increases, applying by definition to all imports, regardless of source. Quotas are eliminated as safeguard measures, since they contradict the basic principles on which the GATT is founded. A revised safeguard Article XIX is envisioned to operate as follows. A country using a temporary tariff increase, here called an excess tariff, would bind itself to a timetable for lifting the safeguard measure. This timetable would specify the dates on which the excess tariff would be reduced as well as the step size of the individual reductions. Noncompliance of the country with this timetable would be a cause for compensation or retaliation by the affected trading partners. In accord with the current GATT rules relating to the unbinding of tariffs, a country would compensate its affected trading partners when it imposed a temporary excess tariff. Compensation payments should probably be automated to take the controversy out of them. A provision could be added to the safeguard article that would automatically transfer all tariff revenue on the product subject to an excess tariff, or a multiple thereof, to the governments of the affected exporting countries. To avoid the problem of prohibitive tariffs, the use of excess tariffs under the safeguard article could be conditioned on some minimum-access provision similar in spirit to that currently written into Article XI:2(c) of the General Agreement.

It is understood that Article XI:2(c) would be discarded in its present form, which limits it to agricultural or fishery products, because comprehensive tariffication implies that all special sectoral provisions are eliminated from the General Agreement. Article XI:2 could be rewritten so as to apply to all trade regardless of sector and whenever a country uses any import restriction other than its bound base tariffs. (In this context, "other import restrictions" means excess tariffs as applied under Article XIX, since this is the only legal escape mechanism under the suggested system of comprehensive tariffication.) A provision could be added to ensure that the market share reserved for imports would be distributed in a nondiscriminatory way. Reference could be made to Article XIII of the General Agreement for that purpose.

A question arising in this context relates to the conditions under which a country should be allowed to resort to excess tariffs. The criteria that currently apply for safeguard actions according to Article XIX could be extended to the revised safeguard article. Alternatively, the article could be modified along the lines of a more comprehensive definition of injury. For example, it has been suggested that the term "injury" be given an economy-wide perspective rather than limiting its interpretation to the producers of a particular range of products (Laird and Sampson 1987). In any case, the excess tariff provision would be applicable during the adjustment process from the current system of protection to one based solely on bound uniform tariffs. It is expected to be the primary means of achieving a system based only on bound uniform tariffs. Excess tariffs could provide temporary import relief for all products now protected by nontariff barriers with tariff equivalents much greater than the uniform base tariff that a country would adopt after adjusting to the new system.

Countries may resort to gray-area measures to reduce the adjustment pressure that grows from lowering excess tariffs to the level of the bound base tariff over time. In this context, four types of measures are particularly applicable to avoidance of tariffication disciplines: voluntary export restraints, state trading arrangements, domestic subsidies, and exchange-rate manipulations. Their likely significance will be discussed in turn, along with possible ways to contain their use.

In industry, voluntary export restraints could become the preferred way to circumvent the revised safeguard article, just as they have been the preferred mechanism to avoid the current safeguard article (see Sampson 1987 for quantitative evidence). Although voluntary export restraints are less likely to become a major problem in agriculture, they have to be addressed by any reform package that claims, as this one does, to be applicable for trade in general, not only for agricultural trade. Voluntary export restraints could be explicitly prohibited, with the GATT Secretariat actively supervising this prohibition. The Secretariat would have the right to initiate cases against any country that forced export restraint agreements on its trading partners, thus reducing the likelihood of government-sponsored voluntary export restraints. It would not be able, however, to contain export restraint agreements negotiated between companies of importing and exporting countries—an area for domestic cartel legislation, not for the GATT.

Currently, voluntary export restraints are less frequent in agriculture than they are in nonagriculture. One reason for this is the existence of another very popular escape mechanism in agriculture, state trading (see Article XVII). Examples of state trading arrangements just from the dairy sector include butter imports into Canada, butter and milk powder imports into Japan, Swiss butter imports, and dairy exports of New Zealand. Furthermore, most of the trade in wheat and coarse grains is channeled through state trading agencies (see Hathaway 1987). Although Article XVII of the General Agreement stipulates that state trading enterprises are to operate in a manner consistent with the General Agreement, little attention is paid to the relevant GATT rules in practice. In fact, state trading has been a convenient way to impose frontier barriers. It obviates the need to invoke official safeguard measures or provide explicit export subsidies. Yet no GATT dispute has ever been initiated that focused on the practices of state trading enterprises. This is probably because it is generally realized that official complaints are unlikely to bear any fruit, anyway. The rules of Article XVII are simply too loose to be of relevance.

To close this loophole, there is an urgent need for better disciplines on state trading arrangements. Treating export subsidies in agriculture the same way as elsewhere should go a long way in eliminating implicit export subsidies by state trading enterprises in agriculture. Implicit quantitative import restrictions, in contrast, are more difficult to prevent. An outright prohibition of state trading enterprises would be preferable and certainly would be the logical extension of comprehensive tariffication. But such a prohibition is unlikely to be politically feasible. Trying to discipline state trading enterprises through detailed rules on accounting may also be doomed because of the many diverse functions they can be assigned to fulfill. The only practical solution may be to restrict their operations on the import side indirectly through binding the NRP for all those goods under their control. In particular, a provision could be added to Article XVII to the effect that the price difference between the border price and the domestic wholesale price of products under the control of state trading enterprises should not exceed the equivalent of the bound base tariffs for those products.

Domestic subsidies are another possible way of circumventing the disciplines of tariffication. As the discussion in Chapter 5 has shown, they can, at least partially, undo the effect of a reduction in frontier barriers, including the elimination of export subsidies. A possible way of diffusing this potential problem is by adding a quantitative limit on domestic subsidies to the Subsidies Code's Article 11. Per-unit subsidies could, for example, be limited to a level equivalent to the prenegotiation nominal tariff level for the product in question. As an alterna-

tive, subsidy limits could be expressed in terms of a reduced version of the PSE measure, that is, a PSE stripped of its NRP component.⁶⁸ The subsidy equivalent could be expressed as a percent of value added for a given industry or product and limited to a maximum value for all countries. The attraction of such a scheme is twofold. Not only would it limit the influence of domestic subsidies on trade flows, it would also give governments a measure of independence from special interest groups and their ever-present demands for handouts. To put it differently, quantitative limits on subsidies would make rent-seeking less profitable and subsidy-cutting easier to implement—a very important point in light of the rather unsuccessful attempts at subsidy reductions observed in many countries. The possible damage that strict quantitative limits on domestic subsidies could impose on well-thought-out plans for correcting market failures should not be overestimated. In reality, a great many subsidies relating to tradable goods are neither well thought through nor do they attack true market failures.

A quantitative limit on domestic subsidies also has certain disadvantages. As discussed in detail in Chapter 5, domestic subsidies are inherently difficult to identify and quantify. Also, countries differ widely in their attitude toward them. Both points could waste a lot of time and goodwill at the negotiating table relative to the expected benefit of a subsidy limit. If a comprehensive tariffication plan is adopted, the subsidy issue will probably lose much of its importance. Indeed, apart from agriculture, there are few areas where domestic subsidies play a major role in trade. (One distinct exception is the civil aircraft industry in the EC.)

Even in agriculture, domestic subsidies with trade effects are likely to be much less of an issue if rates of protection are made uniform across broad commodity groups in agriculture.⁶⁹ This is the main reason that the above tariffication proposal calls for *uniform* tariffs. Furthermore, as argued at some length in Chapter 4, relatively low frontier barriers to trade imply a relatively high budgetary cost of domestic subsidies to governments. This cost argument contributes to making domestic subsidies less attractive once tariffication has converted the present trading system into one characterized by uniform, relatively low, bound tariffs. Finally, although numerically fixed subsidy levels or ratios would indeed give governments a protective shield with which to ward off demands for handouts in excess of those limits, there is the danger that governments will not be able to resist demands to raise subsidies at least to the levels allowed.

When the arguments for and against a quantitative limit on domestic subsidies are weighed, doubts may arise as to the value of striving for a general solution to the domestic subsidy issue in the Uruguay Round. If domestic subsidies are not believed to present a major issue under a system of uniform tariffs, a case-by-case resolution of domestic subsidies issues may be more efficient and could be accomplished either in negotiations outside of the GATT or by dispute settlement inside the GATT. For successful dispute settlement within the GATT, current procedures would have to be made much more responsive.⁷⁰ This would especially benefit developing countries, whose lack of political or economic influence weakens their position in direct negotiations outside of the GATT.

Government attempts to manipulate exchange rates in order to circumvent the disciplines of tariffication and an export subsidy ban could be handled in the same way as domestic

⁶⁸ The NRP component of PSE, that is, the need to compare border price and domestic price for like products, stands in the way of applying PSE for all products, regardless of sector. This is discussed in more detail in Chapter 5.

⁶⁹ It may be conjectured that the vast differences between the protection rates accorded to grains and those for grain substitutes in the EC are the root cause for a good number of vexing subsidy disputes between the United States and the EC. This applies most apparently to the production and processing subsidies that the EC has given to oilseeds since the late 1970s.

⁷⁰ Some suggestions on revising the GATT's current dispute-settlement procedures are contained, for example, in Institute for International Economics and the Institute for Research on Public Policy 1988.

subsidies, that is, without adding new provisions to the General Agreement or its subsidiary codes law. This is not to deny that consistent currency undervaluations or depreciations that aim at gaining a competitive trade advantage can severely distort trade flows. They can indeed reduce imports on a massive scale and at the same time provide decisive advantages in export markets. For all practical purposes, they are functionally equivalent to a combination of import taxes and export subsidies applied uniformly across sectors. (In this context, note that nothing about the exchange rate makes it unique to agriculture.) Exchange-rate undervaluation is not only of theoretical interest. It has been practiced in the past by West Germany and Japan, among others, and is currently used by such countries as Taiwan and Korea.

In contrast to currency undervaluation, currency overvaluation is of less concern to the GATT (though it is of major concern to the World Bank and the IMF). Currency overvaluation does not displace exports of other countries that would be competitive otherwise, nor does it translate directly into lower imports and reduced market access.⁷¹ Currency overvaluation plays a role for the GATT system only insofar as it may make developing countries less inclined to endorse tariffication. After all, high tariffs are used by many developing countries to compensate for the implicit tax on importables that results from an overvalued exchange rate. Lowering these tariffs would even increase this implicit tax on importables, thereby putting heavy pressure on governments to reduce the degree of exchange-rate misalignment.⁷²

Leaving aside the problem that overvalued exchange rates can pose in getting developing countries to accept the idea of tariffication, the GATT has to be mainly concerned with currency undervaluation. But as there are only a few countries in the world with undervalued exchange rates, this area seems to be ideally suited for a bargaining solution rather than an approach based on complex rules that may be impossible to enforce in practice. Political pressure to adjust the exchange rate, similar to that applied to Korea and Taiwan by the United States in recent times, appears to be the proper way to handle the trade problems resulting from undervalued currencies. Besides, it has to be remembered that an undervalued currency is difficult to maintain in real terms over a prolonged period. Consistent currency undervaluation will eventually lead to higher rates of inflation, with a consequent reduction in international competitiveness. In addition, domestic output growth will increase the demand for imported raw materials and intermediate goods. Eventually, imports will also get a boost from rising personal consumption unless high domestic taxes are levied on imported goods. (This appears to be the case for Korea with regard to foreign-made automobiles, for example.) If such taxes are levied, GATT signatories may file a complaint with the GATT under the provisions of Article XXIII.⁷³ In short, there does not appear to be a compelling reason to settle the exchange-rate issue through amendments to the General Agreement or the addition of a new code.

To summarize, the reform proposal suggested in this study consists of two basic elements: comprehensive tariffication and a prohibition of export subsidies.⁷⁴ In order to keep countries

⁷¹Market access can become restricted indirectly over time, as the import-competing industries in a country with an overvalued exchange rate will lobby for import protection—a phenomenon recently observed in the United States.

⁷²Krueger, Schiff, and Valdés (1988) show that the importables of many developing countries are subject to high positive rates of protection at the official exchange rate, but receive negative protection, that is, they are implicitly taxed, at the corrected exchange rate.

⁷³It may be added that multiple currency practices as opposed to an undervalued exchange rate for all trade is captured by Article VI of the GATT. Such practices can in principle be countervailed. See the text of Article VI and the clarifying interpretations in Appendix 1.

⁷⁴The approach suggested here is close to, though not identical to, the one proposed in *Resources for the Future* 1988.

from circumventing the disciplines of this reform package, a ban on voluntary export restraints and more effective rules of behavior for state trading enterprises seem necessary.

The above package has several advantages over such alternative suggestions for trade reform as fixing overall protection levels. The reform proposal relies on well-known GATT instruments and principles rather than untried policy instruments or measurement techniques. This should ease the transition for trade in agriculture and other industries toward the final objective of little or no government interference. The effort to incorporate a completely new approach such as PSE into the GATT framework could not only deadlock negotiations over measurement concepts and problems, but also establish a special case for agriculture, with all the negative consequences that have already been discussed. In contrast, opting for the reform proposal outlined above would fully integrate agriculture into the GATT framework. In fact, a major strength of the proposal's core element, tariffication, is that it could easily form the basis of trade reform within the GATT for all goods-producing sectors, not just agriculture.⁷⁵ It could be the sought-after unifying theme of the Uruguay Round and hence play a role similar to the "across-the-board" tariff-reduction idea of the Tokyo Round. (See Chapters 3 and 4 for a discussion of the importance of finding such a unifying theme for the Uruguay Round.)

Tariffication has one characteristic that may lessen its appeal to agriculture: it does not by itself guarantee domestic price stability. Unlike the exchange-rate issue, the question of price stability is unique to agricultural products. It also appears to be of considerable importance to both farmers and agricultural policymakers. For example, even sharp critics of the EC's Common Agricultural Policy concede that it has performed well in achieving the stabilization objective. The question arises as to whether the objective of stable prices warrants giving agriculture some special exemptions from the disciplines of tariffication.

Incomplete markets due to adverse selection and moral hazard prevent farmers from obtaining comprehensive insurance against the output and price risks they face. If this is acknowledged as a market failure, government intervention can be justified. (See a complete discussion of price stabilization in Newberry and Stiglitz 1981.) However, it is questionable whether government intervention should take the form of border measures. Probably the only reason to favor border measures to stabilize prices is their low transaction costs compared with some of the alternatives; otherwise, such measures do not seem a good choice. First, the history of the GATT clearly questions the wisdom of special sectoral exemptions. Indeed, most of the problems with agricultural trade have resulted exactly because of such special exemptions. Second, it is far from certain that the extent of price variability that may still be expected in a system based only on tariffs would be large enough to warrant the costs of government intervention.⁷⁶ Although the degree to which world price variability will be less than at present is uncertain, there appears to be no reason to doubt the direction of change. (See Schiff 1985 for a discussion of price variability.) Third, stabilizing domestic price may actually worsen the fluctuations in income if price and quantity are negatively correlated. Fourth, by partially or fully insulating the domestic market from price fluctuations in the world market, border measures worsen the price instability in the world market. This, in turn, tends to raise the problem of price instability for all countries. Price stabilization through border measures has, in other words, negative externalities for other countries. This does not appear to be a desirable outcome from the point of view of global welfare maximization.

Domestic or international insurance schemes that compensate for income losses resulting from price instability seem to be preferable to border measures from the perspective of the

⁷⁵ The ban on export subsidies for agricultural products only serves to bring agriculture up to the same level of GATT disciplines that applies to nonagriculture.

⁷⁶ Quota-like variable levies or similar schemes to insulate domestic farmers from world price fluctuations incur the cost of preventing a country from taking full advantage of its comparative advantage.

General Agreement. Certain mechanisms are already in place to deal with such cases. A number of countries have futures markets, others have insurance schemes for selective risks (crop insurance). (See Stiglitz 1987 for a short discussion of alternative responses to the risk of price instability.) Domestic credit programs or special income tax provisions could alleviate the problems of income fluctuations even further. Developing countries can draw on the IMF's compensatory financing scheme or the EC's Stabex system. If so desired, these mechanisms could certainly be improved. They could even serve as a model for domestic schemes of income averaging.

On the Proposal's Realism

Whether a proposal has a realistic chance of being adopted during the Uruguay Round depends ultimately on its ability to garner enough domestic political support in the major trading nations. It has already been argued at some length in this report that domestic acceptability hinges on a favorable political constellation. It is particularly important that the political power of the groups that stand to lose from a trade reform proposal in the short run be kept in check by a sufficient amount of countervailing power. This means there have to be other special interest groups, apart from consumers, that are strongly in favor of a trade reform and, at the same time, have enough political clout to counter the influence of those groups that oppose the reform.

The influence of special interest groups on the negotiations is greatly increased by sector-specific, commodity-based reform proposals that lead to piecemeal trade arrangements one commodity at a time. Negotiations on this basis are likely to break down or lead the agricultural sector closer to a system of managed trade. The political power needed to counter these special interest groups can be generated to some extent by the aggregate negotiating approach advocated by the United States in the Negotiating Group on Agriculture. If all agricultural support programs for all commodities are negotiated in one package, it is at least possible to trade a country's losses in one commodity group, such as oilseeds, for gains in another commodity group, such as grains. The political influence of a commodity group that is losing can be counteracted by the influence of a commodity group that stands to gain. However, this negotiating approach runs into a problem with countries such as Japan, the Nordic countries, and the EC, which have few or no commodity groups that would gain from a given reform package. This can be solved by negotiating not only agriculture, but all sectors, in one package. Losses in agriculture can thus be compensated for by gains in industry, or vice versa,⁷⁷ and countervailing power is established across sectors and industries. But negotiations across sectors require a unifying principle just as a package deal in agriculture alone needs a unifying negotiating and measurement concept like PSE. Tariffication as defined above, applicable for all sectors and fully compatible with the basic principles of the GATT, could be this unifying theme.

If the negotiations of the Uruguay Round extend across sectors and are based on the idea of tariffication, then their success depends on whether it is possible to find an overall balance of gains and losses for the major trading nations—the United States, the EC, Japan, and the Cairns Group countries. In the remainder of this chapter some of these possible gains and losses are outlined to show that the Uruguay Round could indeed reach an overall agreement. The discussion will center on agriculture.

⁷⁷ Australia, for example, is a country where protection in industry could be more easily reduced if industry were negotiated in a package deal with agriculture, which can expect to gain significantly from a trade reform that opens up domestic markets in all countries.

The trade reform proposal outlined above would mean considerable adjustment pressure for the farmers of countries that are importers of agricultural products but have significant frontier barriers. Japan and the Nordic countries fall into this category. The suggested ban on agricultural export subsidies is probably the least controversial part of the proposal, because export subsidies are used seldom or not at all. Japan, for example, employs export subsidies for rice only sporadically, hence their elimination would not cause much political resistance from farming groups. This is reflected in the trade reform proposals that Japan and the Nordic countries tabled in the Negotiating Group on Agriculture in 1987.

Comprehensive tariffication, including uniformity of tariffs and the dismantling of state trading, poses much more of a threat to farmers in these countries because it would require a substantive restructuring of domestic support policies. The incomes of certain sections of the agricultural sector, that is, producers of particular crops or firms upstream or downstream of agricultural producers, could shrink as a result. Expected income losses, however, or simply uncertainty about future income will cause resistance to reform ideas in the farm community. As there is little or nothing for Japan and the Nordic countries to request as compensation from their trading partners in the area of agriculture, the agricultural sector will be solidly united against reform. Plenty of compensation possibilities exist, however, outside of agriculture. Japanese cars, electronics, and other manufactures, for example, face numerous nontariff barriers in the United States, Australasia, and many developing countries that are actual or potential exporters of agricultural products to Japan. A cross-sectoral reform package that promises new opportunities for industry, balanced by concessions in agriculture, could be of sufficient interest to industry to take on the farm lobby and hence to allow the government some room for compromise at the multilateral trade negotiations.

The case of the EC differs somewhat from that of Japan or the Nordic countries because it is a large and growing net exporter of agricultural products. As export subsidies are an integral part of the Common Agricultural Policy, the EC could and does assert that a ban on export subsidies would be equivalent to fundamentally changing the nature of its internal agricultural policy regime, whereas this would apply to no other country to that extent. In addition, comprehensive tariffication would mean an end to the system of variable levies, another keystone of the Common Agricultural Policy. Hence it seems clear that marginal adjustments of the type implemented by the Common Agricultural Policy in past years would not suffice this time. (The introduction of coresponsibility levies for milk, production quotas for sugar, and decreasing market price support for cereals are examples of these adjustments.)

In order to maintain the incomes of farmers, the Common Agricultural Policy would probably have to be changed over to a system based on direct income support or deficiency payments, possibly along the lines of a combination of production controls and marketing certificates, as outlined in Chapter 5. Although this might not necessarily lower the incomes of farmers in the short run (Koester and Nuppenau 1987), it would certainly cause considerable uncertainty among farmers. In addition, there would be adjustment costs for many vested interests with strong links to farm production. For example, landowners would incur capital losses and the industries upstream and downstream of agricultural production would face a structural adjustment problem, with income losses highly probable in the short to medium run.

Even if certain commodity groups within agriculture could gain from a trade reform as suggested above, it is far from clear who would gain in the end. The many complex distortions introduced by the Common Agricultural Policy make any predictions highly uncertain. Given this high degree of uncertainty, it is unlikely that much support for trade reform will be forthcoming from agriculture. The political power of those groups with a strong vested interest in the status quo can be counteracted only with sufficient pressure from outside of agriculture. In this sense, the situation in the EC is not very different from that in Japan and the Nordic countries.

In another sense, the EC differs from Japan in agriculture because trade reform, as outlined above, would give the EC something in agriculture that it has long desired, tariff harmonization. It has to be remembered in this context that tariffication, as defined above, rests on relatively low base tariffs that are uniform within broad commodity groups. (The base tariffs will prevail after an adjustment period during which countries will use excess tariffs according to a revised safeguard Article XIX to ease the transition to the new system based solely on tariffs.) Uniformity of tariffs is a means of minimizing distortions that are generated by differences in effective protection rates; thus it removes one strong incentive for domestic subsidies. For example, even without changing the current system of the Common Agricultural Policy, there would be no EC subsidy program for oilseeds if the EC could raise the tariffs for oilseeds and the feed substitutes manioc (cassava), corn gluten, and citrus pellets from close to zero to a level that matches the protection level for grains. (This is not to say that harmonizing protection levels for feed substitutes upward to the level currently pertaining to grains is, *per se*, a good idea.)

Harmonization of EC tariffs would have considerable effects on other countries, even if the uniform base tariffs were fixed at a level much lower than those rates of protection now common for most agricultural commodities produced by the EC. Strong opposition by the oilseed and feed-substitute commodity groups would have to be overcome in the United States, Thailand, Argentina, and Brazil, to name only a few countries. Comprehensive tariffication, then, if applied to the EC case, clearly invalidates the argument that only the EC—not the United States—would have to accede in agriculture.

Is there anything worthwhile that the United States and other affected countries would gain from uniform base tariffs in the EC? If the answer is yes, there is a chance that sufficient countervailing power can develop against the strong opposition of those commodity groups that stand to lose. Before turning to the various repercussions of tariff harmonization, though, it seems worthwhile to mention briefly a basic point relating to negotiation strategy.

In the absence of some form of tariff harmonization, the EC is not going to let the feed-substitute issue rest in peace. The budgetary pressure is simply too high. Domestic subsidies will continue, and production will increase and gradually displace a growing quantity of imports. Countries with less political and economic power than the United States, such as Thailand, will have to cut back their exports because of tighter voluntary export restraints. (The EC has already concluded a voluntary export restraint on manioc with Thailand that reduced Thai exports to the EC from about 8 million tons to 5 million tons.) What all this means is that the economic value of the zero-tariff binding for feed substitutes will diminish over time. (This fear is behind the U.S. initiative to bring the feed subsidies of the EC before a GATT panel.) If present trends continue, its economic value is likely to be zero in a few years, unless two unknowns are assumed: a clear decision by a GATT panel against the EC oilseed subsidy program and the willingness of the EC to abide by it.

The basic idea of tariffication is that relatively low uniform tariffs replace the current system of protection after some period of adjustment. Lower rates of protection in the EC for all agricultural products and the absence of export subsidies will mean much better market conditions for many traded commodities, particularly grains, beef, and sugar. The keystone commodity group for U.S. agriculture consists of grains. Better market conditions here are likely to translate into considerable political support for trade reform that could more than compensate for the negative attitude of feed-substitute and oilseed producers.

It is certain that the producers of feed substitutes and oilseeds are going to lose from tariffication. It would mean an end to the rents they now receive by being able to sell at zero duty in the EC market that is otherwise highly protected. The following changes can be anticipated. The drop in the price of citrus pellets would lower, *ceteris paribus*, the profits of the producers of citrus juices and its derivatives. However, since tariffication would also mean lower frontier barriers for the latter products, particularly in Japan, the benefits of an

expanding market would probably compensate for the drop in profits resulting from higher production costs.

The virtual loss of the corn gluten market in the EC would raise the production costs of the wet-corn milling industry in the United States, thereby pushing down profits on high-fructose sweeteners, ethanol, and a range of other products made from corn. A further drop in profits would result from the likely world price increase in corn, the industry's basic input. As tariffication would also end U.S. quotas on sugar, the U.S. sugar price would fall considerably. Since sugar is the industry's basic competing product, corn sweetener production would become even less profitable. As a result, sugar might regain some of its lost ground or at least not lose much more in the United States because of trade reform.

Lower prices for all feed substitutes relative to coarse grains might displace some grain from use for feed. Hence the production costs in the United States for pork, poultry, beef, and dairy products might not go up, despite a likely price increase in grains, so there would not be a squeeze on profits from the cost side. Lower protection rates on dairy products, however, could reduce profits from the output side.

High protection rates on feedgrains, together with zero-tariff bindings on feed substitutes in the EC, have made Thailand a large exporter to the EC of the feedgrain substitute manioc. Similarly, Brazil and Argentina supply oilseed meals to the EC. Tariff harmonization in the EC would mean sharply reduced EC imports of both types of feeds. As this translates into immediate income losses for feed-substitute producers in these countries, the question of compensation becomes of crucial importance. Internal support for a trade reform based on tariffication can be mobilized only if large enough gains through better market access can be expected in other products, inside or outside of agriculture. Such gains are indeed very likely. Better export opportunities, in both the EC and third markets, are certain in a number of products that are both heavily subsidized by the EC and of particular interest to Argentina, Brazil, and Thailand. These products are grains for Argentina, beef for Argentina and Brazil, and sugar for Brazil, to name only the most important agricultural products. Apart from that, tariffication would translate into better market access for textiles and clothing for both Brazil and Thailand. Thailand could also expect to benefit in other products. Since tariffication also applies to the United States and Japan, Thai rice producers could expect significant gains, as the United States would stop subsidizing its rice exports and Japan would lower its barriers for rice imports.⁷⁸

In short, those countries that are negatively affected by tariff harmonization between grains and grain substitutes in the EC would be expected to get sizable economic benefits from tariffication. As the economic gains would be reaped to a large extent by agricultural commodity groups with considerable domestic clout, it is unlikely that comprehensive tariffication will fail because of the opposition of producers of feedgrain substitutes.

Comprehensive tariffication, however, would also affect other commodity groups. In particular, it would imply that the trade preferences the EC is granting under the Lomé Agreement to ACP countries would lose much of their value. This issue was examined at some length earlier, hence it is sufficient to point out here the similarity between ACP tariff preferences and the zero-tariff binding for feedgrain substitutes. Tariffication would mean an end to quota rents in both cases. But as all countries switch to tariffication, export opportunities open up in other markets, not only in the particular product where quota rents are lost, but in general. Export opportunities are likely to improve, not worsen, when market access in selected products and countries is exchanged for improved market access in all products and all countries. This point

⁷⁸ The Japanese rice policy is analyzed in Otsuka and Hayami 1985. The world rice market and Thailand's role in it is detailed in Siamwalla and Haykin 1983.

applies not only to developing countries that fear for their quota rents, but where equal harm to others that think tariff increases due to tariffication (tariff harmonization) will do them more harm than good. In this context, it should be remembered that low tariffs alone do not guarantee market access. Seasonal quotas, tariff quotas, and a host of other schemes are currently used to nullify low tariffs. The idea of tariffication is to eliminate these import barriers and along with them the high degree of uncertainty about market access.

A switch to a tariffs-only system would require significant adjustments in the agricultural sector of the United States that would extend far beyond the structural adjustment problems faced by oilseed producers mentioned above. For example, export subsidies would have to stop. Since the 1985 U.S. Farm Bill was passed, export subsidies have been used for numerous commodities ranging from beef and dairy to grains, although not to the extent common in the EC (see cases cited in Chapter 5). Further, the current system of deficiency payments, by which payments are made for all production regardless of domestic or export use, would have to be revised. Seasonal import restrictions on fruit and vegetables would have to be phased out. Above all, the section 22 waiver, granting the right to impose quotas at will without compensation, would have to be given up by the United States and would affect beef, sugar, and dairy producers. It is unlikely that they will be easily convinced of the merits of trade reform. However, the lobby that is in favor of trade reform can be expected to be strong in the United States. Within agriculture, grain producers can be counted on for support because their potential gains from worldwide tariffication are the most obvious. The strongest support for trade reform, however, is likely to come from outside of agriculture, that is, from industry and the services. The concessions in agriculture—tariff harmonization and the elimination of the section 22 waiver—could be used to obtain compensating concessions in areas outside of agriculture. In practice, this would mean that LDCs compromise in industrial goods, intellectual property rights, trade-related investment measures, and services.⁷⁹ It would also imply a commitment by the Cairns Group countries (particularly Australasia), which gain from trade reform in agriculture more than any other country or country group, to open up their markets for industrial goods and services.

⁷⁹ The willingness of LDCs and, in particular, the newly industrialized countries to compromise in these areas could be reinforced considerably if the United States as well as all other industrial countries could agree to extend tariffication unconditionally to light industries such as textiles and clothing, that is, industries that are of particular interest to LDCs.

APPENDIX 1: SELECTED ARTICLES OF THE GENERAL AGREEMENT

Article VI

Anti-dumping and Countervailing Duties

1. The contracting parties recognize that dumping, by which products of one country are introduced into the commerce of another country at less than the normal value of the products, is to be condemned if it causes or threatens material injury to an established industry in the territory of a contracting party or materially retards the establishment of a domestic industry. For the purposes of this Article, a product is to be considered as being introduced into the commerce of an importing country at less than its normal value, if the price of the product exported from one country to another

- (a) is less than the comparable price, in the ordinary course of trade, for the like product when destined for consumption in the exporting country, or,
- (b) in the absence of such domestic price, is less than either
 - (i) the highest comparable price for the like product for export to any third country in the ordinary course of trade, or
 - (ii) the cost of production of the product in the country of origin plus a reasonable addition for selling cost and profit.

Due allowance shall be made in each case for differences in conditions and terms of sale, for differences in taxation, and for other differences affecting price comparability.*

2. In order to offset or prevent dumping, a contracting party may levy on any dumped product an anti-dumping duty not greater in amount than the margin of dumping in respect of such product. For the purposes of this Article, the margin of dumping is the price difference determined in accordance with the provisions of paragraph 1.*

* refers to interpretative notes at the end of this appendix.

3. No countervailing duty shall be levied on any product of the territory of any contracting party imported into the territory of another contracting party in excess of an amount equal to the estimated bounty or subsidy determined to have been granted, directly or indirectly, on the manufacture, production or export of such product in the country of origin or exportation, including any special subsidy to the transportation of a particular product. The term "countervailing duty" shall be understood to mean a special duty levied for the purpose of offsetting any bounty or subsidy bestowed, directly or indirectly, upon the manufacture, production or export of any merchandise.*

4. No product of the territory of any contracting party imported into the territory of any other contracting party shall be subject to anti-dumping or countervailing duty by reason of the exemption of such product from duties or taxes borne by the like product when destined for consumption in the country of origin or exportation, or by reason of the refund of such duties or taxes.

5. No product of the territory of any contracting party imported into the territory of any other contracting party shall be subject to both anti-dumping and countervailing duties to compensate for the same situation of dumping or export subsidization.

6. (a) No contracting party shall levy any anti-dumping or countervailing duty on the importation of any product of the territory of another contracting party unless it determines that the effect of the dumping or subsidization, as the case may be, is such as to cause or threaten material injury to an established domestic industry, or is such as to retard materially the establishment of a domestic industry.

(b) The CONTRACTING PARTIES may waive the requirement of sub-paragraph (a) of this paragraph so as to permit a contracting party to levy an anti-dumping or countervailing duty on the importation of any product for the purpose of offsetting dumping or subsidization which causes or threatens material injury to an industry in the territory of another contracting party exporting the product concerned to the territory of the importing contracting party. The CONTRACTING PARTIES shall waive the requirements of sub-paragraph (a) of this paragraph, so as to permit the levying of a countervailing duty, in cases in which they find that a subsidy is causing or threatening material injury to an industry in the territory of another contracting party exporting the product concerned to the territory of the importing contracting party.*

(c) In exceptional circumstances, however, where delay might cause damage which would be difficult to repair, a contracting party may levy a countervailing duty for the purpose referred to in sub-paragraph (b) of this paragraph without the prior approval of the CONTRACTING PARTIES; *Provided* that such action shall be reported immediately to the CONTRACTING PARTIES and that the countervailing duty shall be withdrawn promptly if the CONTRACTING PARTIES disapprove.

7. A system for the stabilization of the domestic price or of the return to domestic producers of a primary commodity, independently of the movements of export prices, which results at times in the sale of the commodity for export at a price lower than the comparable price charged for the like commodity to buyers in the domestic market, shall be presumed not to result in material injury within the meaning of paragraph 6 if it is determined by consultation among the contracting parties substantially interested in the commodity concerned that:

- (a) the system has also resulted in the sale of the commodity for export at a price higher than the comparable price charged for the like commodity to buyers in the domestic market, and
- (b) the system is so operated, either because of the effective regulation of production, or otherwise, as not to stimulate exports unduly or otherwise seriously prejudice the interests of other contracting parties.

Article XI *

General Elimination of Quantitative Restrictions

1. No prohibitions or restrictions other than duties, taxes or other charges, whether made effective through quotas, import or export licences or other measures, shall be instituted or maintained by any contracting party on the importation of any product of the territory of any other contracting party or on the exportation or sale for export of any product destined for the territory of any other contracting party.

2. The provisions of paragraph 1 of this Article shall not extend to the following:

- (a) Export prohibitions or restrictions temporarily applied to prevent or relieve critical shortages of foodstuffs or other products essential to the exporting contracting party;

- (b) Import and export prohibitions or restrictions necessary to the application of standards or regulations for the classification, grading or marketing of commodities in international trade;
- (c) Import restrictions on any agricultural or fisheries product, imported in any form,* necessary to the enforcement of governmental measures which operate:
 - (i) to restrict the quantities of the like domestic product permitted to be marketed or produced, or, if there is no substantial domestic production of the like product of a domestic product for which the imported product can be directly substituted; or
 - (ii) to remove a temporary surplus of the like domestic product, or, if there is no substantial domestic production of the like product, of a domestic product for which the imported product can be directly substituted, by making the surplus available to certain groups of domestic consumers free of charge or at prices below the current market level; or
 - (iii) to restrict the quantities permitted to be produced of any animal product the production of which is directly dependent, wholly or mainly, on the imported commodity, if the domestic production of that commodity is relatively negligible.

Any contracting party applying restrictions on the importation of any product pursuant to sub-paragraph (c) of this paragraph shall give public notice of the total quantity or value of the product permitted to be imported during a specified future period and of any change in such quantity or value. Moreover, any restrictions applied under (i) above shall not be such as will reduce the total of imports relative to the total of domestic production, as compared with the proportion which might reasonably be expected to rule between the two in the absence of restrictions. In determining this proportion, the contracting party shall pay due regard to the proportion prevailing during a previous representative period and to any special factors* which may have affected or may be affecting the trade in the product concerned.

Article XIII *

Non-discriminatory Administration of Quantitative Restrictions

1. No prohibition or restriction shall be applied by any contracting party on the importation of any product of the territory of any other

contracting party or on the exportation of any product destined for the territory of any other contracting party, unless the importation of the like product of all third countries or the exportation of the like product to all third countries is similarly prohibited or restricted.

2. In applying import restrictions to any product, contracting parties shall aim at a distribution of trade in such product approaching as closely as possible the shares which the various contracting parties might be expected to obtain in the absence of such restrictions, and to this end shall observe the following provisions:

- (a) Wherever practicable, quotas representing the total amount of permitted imports (whether allocated among supplying countries or not) shall be fixed, and notice given of their amount in accordance with paragraph 3 (b) of this Article;
- (b) In cases in which quotas are not practicable, the restrictions may be applied by means of import licences or permits without a quota;
- (c) Contracting parties shall not, except for purposes of operating quotas allocated in accordance with sub-paragraph (d) of this paragraph, require that import licences or permits be utilized for the importation of the product concerned from a particular country or source;
- (d) In cases in which a quota is allocated among supplying countries, the contracting party applying the restrictions may seek agreement with respect to the allocation of shares in the quota with all other contracting parties having a substantial interest in supplying the product concerned. In cases in which this method is not reasonably practicable, the contracting party concerned shall allot to contracting parties having a substantial interest in supplying the product shares based upon the proportions, supplied by such contracting parties during a previous representative period, of the total quantity or value of imports of the product, due account being taken of any special factors which may have affected or may be affecting the trade in the product. No conditions or formalities shall be imposed which would prevent any contracting party from utilizing fully the share of any such total quantity or value which has been allotted to it, subject to importation being made within any prescribed period to which the quota may relate.*

3. (a) In cases in which import licences are issued in connection with import restrictions, the contracting party applying the restrictions shall provide, upon the request of any contracting party having an interest in

the trade in the product concerned, all relevant information concerning the administration of the restrictions, the import licences granted over a recent period and the distribution of such licences among supplying countries; *Provided* that there shall be no obligation to supply information as to the names of importing or supplying enterprises.

(b) In the case of import restrictions involving the fixing of quotas, the contracting party applying the restrictions shall give public notice of the total quantity or value of the product or products which will be permitted to be imported during a specified future period and of any change in such quantity or value. Any supplies of the product in question which were *en route* at the time at which public notice was given shall not be excluded from entry; *Provided* that they may be counted so far as practicable, against the quantity permitted to be imported in the period in question, and also, where necessary, against the quantities permitted to be imported in the next following period or periods; and *Provided* further that if any contracting party customarily exempts from such restrictions products entered for consumption or withdrawn from warehouse for consumption during a period of thirty days after the day of such public notice, such practice shall be considered full compliance with this sub-paragraph.

(c) In the case of quotas allocated among supplying countries, the contracting party applying the restrictions shall promptly inform all other contracting parties having an interest in supplying the product concerned of the shares in the quota currently allocated, by quantity or value, to the various supplying countries and shall give public notice thereof.

4. With regard to restrictions applied in accordance with paragraph 2 (d) of this Article or under paragraph 2 (c) of Article XI, the selection of a representative period for any product and the appraisal of any special factors * affecting the trade in the product shall be made initially by the contracting party applying the restriction; *Provided* that such contracting party shall, upon the request of any other contracting party having a substantial interest in supplying that product or upon the request of the CONTRACTING PARTIES, consult promptly with the other contracting party or the CONTRACTING PARTIES regarding the need for an adjustment of the proportion determined or of the base period selected, or for the reappraisal of the special factors involved, or for the elimination of conditions, formalities or any other provisions established unilaterally relating to the allocation of an adequate quota or its unrestricted utilization.

5. The provisions of this Article shall apply to any tariff quota instituted or maintained by any contracting party, and, in so far as applicable, the principles of this Article shall also extend to export restrictions.

Article XVI *

Subsidies

Section A—Subsidies in General

1. If any contracting party grants or maintains any subsidy, including any form of income or price support, which operates directly or indirectly to increase exports of any product from, or to reduce imports of any product into, its territory, it shall notify the CONTRACTING PARTIES in writing of the extent and nature of the subsidization, of the estimated effect of the subsidization on the quantity of the affected product or products imported into or exported from its territory and of the circumstances making the subsidization necessary. In any case in which it is determined that serious prejudice to the interests of any other contracting party is caused or threatened by any such subsidization, the contracting party granting the subsidy shall, upon request, discuss with the other contracting party or parties concerned, or with the CONTRACTING PARTIES, the possibility of limiting the subsidization.

Section B—Additional Provisions on Export Subsidies *

2. The contracting parties recognize that the granting by a contracting party of a subsidy on the export of any product may have harmful effects for other contracting parties, both importing and exporting, may cause undue disturbance to their normal commercial interests, and may hinder the achievement of the objectives of this Agreement.

3. Accordingly, contracting parties should seek to avoid the use of subsidies on the export of primary products. If, however, a contracting party grants directly or indirectly any form of subsidy which operates to increase the export of any primary product from its territory, such subsidy shall not be applied in a manner which results in that contracting party having more than an equitable share of world export trade in that product, account being taken of the shares of the contracting parties in such trade in the product during a previous representative period, and any special factors which may have affected or may be affecting such trade in the product.*

4. Further, as from 1 January 1958 or the earliest practicable date thereafter, contracting parties shall cease to grant either directly or indirectly any form of subsidy on the export of any product other than a primary product which subsidy results in the sale of such product for export

at a price lower than the comparable price charged for the like product to buyers in the domestic market. Until 31 December 1957 no contracting party shall extend the scope of any such subsidization beyond that existing on 1 January 1955 by the introduction of new, or the extension of existing, subsidies.*

5. The CONTRACTING PARTIES shall review the operation of the provisions of this Article from time to time with a view to examining its effectiveness, in the light of actual experience, in promoting the objectives of this Agreement and avoiding subsidization seriously prejudicial to the trade or interests of contracting parties.

Article XVII

State Trading Enterprises

1.* (a) Each contracting party undertakes that if it establishes or maintains a State enterprise, wherever located, or grants to any enterprise, formally or in effect, exclusive or special privileges,* such enterprise shall, in its purchases or sales involving either imports or exports, act in a manner consistent with the general principles of non-discriminatory treatment prescribed in this Agreement for governmental measures affecting imports or exports by private traders.

(b) The provisions of sub-paragraph (a) of this paragraph shall be understood to require that such enterprises shall, having due regard to the other provisions of this Agreement, make any such purchases or sales solely in accordance with commercial considerations,* including price, quality, availability, marketability, transportation and other conditions of purchase or sale, and shall afford the enterprises of the other contracting parties adequate opportunity, in accordance with customary business practice, to compete for participation in such purchases or sales.

(c) No contracting party shall prevent any enterprise (whether or not an enterprise described in sub-paragraph (a) of this paragraph) under its jurisdiction from acting in accordance with the principles of sub-paragraphs (a) and (b) of this paragraph.

2. The provisions of paragraph 1 of this Article shall not apply to imports of products for immediate or ultimate consumption in governmental use and not otherwise for resale or use in the production of goods* for sale. With respect to such imports, each contracting party shall accord to the trade of the other contracting parties fair and equitable treatment.

3. The contracting parties recognize that enterprises of the kind described in paragraph 1 (a) of this Article might be operated so as to create serious obstacles to trade; thus negotiations on a reciprocal and mutually advantageous basis designed to limit or reduce such obstacles are of importance to the expansion of international trade.*

4. (a) Contracting parties shall notify the CONTRACTING PARTIES of the products which are imported into or exported from their territories by enterprises of the kind described in paragraph 1 (a) of this Article.

(b) A contracting party establishing, maintaining or authorizing an import monopoly of a product, which is not the subject of a concession under Article II, shall, on the request of another contracting party having a substantial trade in the product concerned, inform the CONTRACTING PARTIES of the import mark-up* on the product during a recent representative period, or, when it is not possible to do so, of the price charged on the resale of the product.

(c) The CONTRACTING PARTIES may, at the request of a contracting party which has reason to believe that its interests under this Agreement are being adversely affected by the operations of an enterprise of the kind described in paragraph 1 (a), request the contracting party establishing, maintaining or authorizing such enterprise to supply information about its operations related to the carrying out of the provisions of this Agreement.

(d) The provisions of this paragraph shall not require any contracting party to disclose confidential information which would impede law enforcement or otherwise be contrary to the public interest or would prejudice the legitimate commercial interests of particular enterprises.

Article XIX

Emergency Action on Imports of Particular Products

1. (a) If, as a result of unforeseen developments and of the effect of the obligations incurred by a contracting party under this Agreement, including tariff concessions, any product is being imported into the territory of that contracting party in such increased quantities and under such conditions as to cause or threaten serious injury to domestic producers in that territory of like or directly competitive products, the contracting party shall be free, in respect of such product, and to the extent and for such time as may be necessary to prevent or remedy such injury, to suspend the obligation in whole or in part or to withdraw or modify the concession.

(b) If any product, which is the subject of a concession with respect to a preference, is being imported into the territory of a contracting party in the circumstances set forth in sub-paragraph (a) of this paragraph, so as to cause or threaten serious injury to domestic producers of like or directly competitive products in the territory of a contracting party which receives or received such preference, the importing contracting party shall be free, if that other contracting party so requests, to suspend the relevant obligation in whole or in part or to withdraw or modify the concession in respect of the product, to the extent and for such time as may be necessary to prevent or remedy such injury.

2. Before any contracting party shall take action pursuant to the provisions of paragraph 1 of this Article, it shall give notice in writing to the CONTRACTING PARTIES as far in advance as may be practicable and shall afford the CONTRACTING PARTIES and those contracting parties having a substantial interest as exporters of the product concerned an opportunity to consult with it in respect of the proposed action. When such notice is given in relation to a concession with respect to a preference, the notice shall name the contracting party which has requested the action. In critical circumstances, where delay would cause damage which it would be difficult to repair, action under paragraph 1 of this Article may be taken provisionally without prior consultation, on the condition that consultation shall be effected immediately after taking such action.

3. (a) If agreement among the interested contracting parties with respect to the action is not reached, the contracting party which proposes to take or continue the action shall, nevertheless, be free to do so, and if such action is taken or continued, the affected contracting parties shall then be free, not later than ninety days after such action is taken, to suspend, upon the expiration of thirty days from the day on which written notice of such suspension is received by the CONTRACTING PARTIES, the application to the trade of the contracting party taking such action, or, in the case envisaged in paragraph 1 (b) of this Article, to the trade of the contracting party requesting such action, of such substantially equivalent concessions or other obligations under this Agreement the suspension of which the CONTRACTING PARTIES do not disapprove.

(b) Notwithstanding the provisions of sub-paragraph (a) of this paragraph, where action is taken under paragraph 2 of this Article without prior consultation and causes or threatens serious injury in the territory of a contracting party to the domestic producers of products affected by the action, that contracting party shall, where delay would cause damage difficult to repair, be free to suspend, upon the taking of the action and

throughout the period of consultation, such concessions or other obligations as may be necessary to prevent or remedy the injury.

Article XX

General Exceptions

Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures:

- (a) necessary to protect public morals;
- (b) necessary to protect human, animal or plant life or health;
- (c) relating to the importation or exportation of gold or silver;
- (d) necessary to secure compliance with laws or regulations which are not inconsistent with the provisions of this Agreement, including those relating to customs enforcement, the enforcement of monopolies operated under paragraph 4 of Article II and Article XVII, the protection of patents, trade marks and copyrights, and the prevention of deceptive practices;
- (e) relating to the products of prison labour;
- (f) imposed for the protection of national treasures of artistic, historic or archaeological value;
- (g) relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption;
- (h) undertaken in pursuance of obligations under any intergovernmental commodity agreement which conforms to criteria submitted to the CONTRACTING PARTIES and not disapproved by them or which is itself so submitted and not so disapproved;*
- (i) involving restrictions on exports of domestic materials necessary to ensure essential quantities of such materials to a domestic processing industry during periods when the domestic price of such materials is held below the world price as part of a governmental stabilization plan; *Provided* that such restrictions shall not operate to increase the exports of or the protection afforded to such

domestic industry, and shall not depart from the provisions of this Agreement relating to non-discrimination;

- (j) essential to the acquisition or distribution of products in general or local short supply; *Provided* that any such measures shall be consistent with the principle that all contracting parties are entitled to an equitable share of the international supply of such products, and that any such measures, which are inconsistent with the other provisions of this Agreement shall be discontinued as soon as the conditions giving rise to them have ceased to exist. The CONTRACTING PARTIES shall review the need for this sub-paragraph not later than 30 June 1960.

Article XXII

Consultation

1. Each contracting party shall accord sympathetic consideration to, and shall afford adequate opportunity for consultation regarding, such representations as may be made by another contracting party with respect to any matter affecting the operation of this Agreement.

2. The CONTRACTING PARTIES may, at the request of a contracting party, consult with any contracting party or parties in respect of any matter for which it has not been possible to find a satisfactory solution through consultation under paragraph 1.

Article XXIII

Nullification or Impairment

1. If any contracting party should consider that any benefit accruing to it directly or indirectly under this Agreement is being nullified or impaired or that the attainment of any objective of the Agreement is being impeded as the result of

- (a) the failure of another contracting party to carry out its obligations under this Agreement, or
- (b) the application by another contracting party of any measure, whether or not it conflicts with the provisions of this Agreement, or
- (c) the existence of any other situation,

the contracting party may, with a view to the satisfactory adjustment of the matter, make written representations or proposals to the other con-

contracting party or parties which it considers to be concerned. Any contracting party thus approached shall give sympathetic consideration to the representations or proposals made to it.

2. If no satisfactory adjustment is effected between the contracting parties concerned within a reasonable time, or if the difficulty is of the type described in paragraph 1 (c) of this Article, the matter may be referred to the CONTRACTING PARTIES. The CONTRACTING PARTIES shall promptly investigate any matter so referred to them and shall make appropriate recommendations to the contracting parties which they consider to be concerned, or give a ruling on the matter, as appropriate. The CONTRACTING PARTIES may consult with contracting parties, with the Economic and Social Council of the United Nations and with any appropriate inter-governmental organization in cases where they consider such consultation necessary. If the CONTRACTING PARTIES consider that the circumstances are serious enough to justify such action, they may authorize a contracting party or parties to suspend the application to any other contracting party or parties of such concessions or other obligations under this Agreement as they determine to be appropriate in the circumstances. If the application to any contracting party of any concession or other obligation is in fact suspended, that contracting party shall then be free, not later than sixty days after such action is taken, to give written notice to the Executive Secretary¹ to the CONTRACTING PARTIES of its intention to withdraw from this Agreement and such withdrawal shall take effect upon the sixtieth day following the day on which such notice is received by him.

Article XXVIII *

Modification of Schedules

1. On the first day of each three-year period, the first period beginning on 1 January 1958 (or on the first day of any other period * that may be specified by the CONTRACTING PARTIES by two-thirds of the votes cast) a contracting party (hereafter in this Article referred to as the "applicant contracting party") may, by negotiation and agreement with any contracting party with which such concession was initially negotiated and with any other contracting party determined by the CONTRACTING PARTIES to have a principal supplying interest* (which two preceding categories of contracting

¹ Since changed to Director-General.

parties, together with the applicant contracting party, are in this Article hereinafter referred to as the "contracting parties primarily concerned"), and subject to consultation with any other contracting party determined by the CONTRACTING PARTIES to have a substantial interest* in such concession, modify or withdraw a concession* included in the appropriate Schedule annexed to this Agreement.

2. In such negotiations and agreement, which may include provision for compensatory adjustment with respect to other products, the contracting parties concerned shall endeavour to maintain a general level of reciprocal and mutually advantageous concessions not less favourable to trade than that provided for in this Agreement prior to such negotiations.

3. (a) If agreement between the contracting parties primarily concerned cannot be reached before 1 January 1958 or before the expiration of a period envisaged in paragraph 1 of this Article, the contracting party which proposes to modify or withdraw the concession shall, nevertheless, be free to do so and if such action is taken any contracting party with which such concession was initially negotiated, any contracting party determined under paragraph 1 to have a principal supplying interest and any contracting party determined under paragraph 1 to have a substantial interest shall then be free not later than six months after such action is taken, to withdraw, upon the expiration of thirty days from the day on which written notice of such withdrawal is received by the CONTRACTING PARTIES, substantially equivalent concessions initially negotiated with the applicant contracting party.

(b) If agreement between the contracting parties primarily concerned is reached but any other contracting party determined under paragraph 1 of this Article to have a substantial interest is not satisfied, such other contracting party shall be free, not later than six months after action under such agreement is taken, to withdraw, upon the expiration of thirty days from the day on which written notice of such withdrawal is received by the CONTRACTING PARTIES, substantially equivalent concessions initially negotiated with the applicant contracting party.

4. The CONTRACTING PARTIES may, at any time, in special circumstances, authorize* a contracting party to enter into negotiations for modification or withdrawal of a concession included in the appropriate Schedule annexed to this Agreement subject to the following procedures and conditions:

(a) Such negotiations* and any related consultations shall be conducted in accordance with the provisions of paragraphs 1 and 2 of this Article.

- (b) If agreement between the contracting parties primarily concerned is reached in the negotiations, the provisions of paragraph 3 (b) of this Article shall apply.
- (c) If agreement between the contracting parties primarily concerned is not reached within a period of sixty days* after negotiations have been authorized, or within such longer period as the CONTRACTING PARTIES may have prescribed, the applicant contracting party may refer the matter to the CONTRACTING PARTIES.
- (d) Upon such reference, the CONTRACTING PARTIES shall promptly examine the matter and submit their views to the contracting parties primarily concerned with the aim of achieving a settlement. If a settlement is reached, the provisions of paragraph 3 (b) shall apply as if agreement between the contracting parties primarily concerned had been reached. If no settlement is reached between the contracting parties primarily concerned, the applicant contracting party shall be free to modify or withdraw the concession, unless the CONTRACTING PARTIES determine that the applicant contracting party has unreasonably failed to offer adequate compensation.* If such action is taken, any contracting party with which the concession was initially negotiated, any contracting party determined under paragraph 4 (a) to have a principal supplying interest and any contracting party determined under paragraph 4 (a) to have a substantial interest, shall be free, not later than six months after such action is taken, to modify or withdraw, upon the expiration of thirty days from the day on which written notice of such withdrawal is received by the CONTRACTING PARTIES, substantially equivalent concessions initially negotiated with the applicant contracting party.

5. Before 1 January 1958 and before the end of any period envisaged in paragraph 1 a contracting party may elect by notifying the CONTRACTING PARTIES to reserve the right, for the duration of the next period, to modify the appropriate Schedule in accordance with the procedures of paragraphs 1 to 3. If a contracting party so elects, other contracting parties shall have the right, during the same period, to modify or withdraw, in accordance with the same procedures, concessions initially negotiated with that contracting party.

Interpretative Notes to the Articles

Ad Article VI

Paragraph 1

1. Hidden dumping by associated houses (that is, the sale by an importer at a price below that corresponding to the price invoiced by an exporter with whom the importer is associated, and also below the price in the exporting country) constitutes a form of price dumping with respect to which the margin of dumping may be calculated on the basis of the price at which the goods are resold by the importer.

2. It is recognized that, in the case of imports from a country which has a complete or substantially complete monopoly of its trade and where all domestic prices are fixed by the State, special difficulties may exist in determining price comparability for the purposes of paragraph 1, and in such cases importing contracting parties may find it necessary to take into account the possibility that a strict comparison with domestic prices in such a country may not always be appropriate.

Paragraphs 2 and 3

1. As in many other cases in customs administration, a contracting party may require reasonable security (bond or cash deposit) for the payment of anti-dumping or countervailing duty pending final determination of the facts in any case of suspected dumping or subsidization.

2. Multiple currency practices can in certain circumstances constitute a subsidy to exports which may be met by countervailing duties under paragraph 3 or can constitute a form of dumping by means of a partial depreciation of a country's currency which may be met by action under paragraph 2. By "multiple currency practices" is meant practices by governments or sanctioned by governments.

Paragraph 6 (b)

Waivers under the provisions of this sub-paragraph shall be granted only on application by the contracting party proposing to levy an anti-dumping or countervailing duty, as the case may be.

Ad Articles XI, XII, XIII, XIV and XVIII

Throughout Articles XI, XII, XIII, XIV and XVIII, the terms "import restrictions" or "export restrictions" include restrictions made effective through state-trading operations.

Ad Article XI

Paragraph 2 (c)

The term "in any form" in this paragraph covers the same products when in an early stage of processing and still perishable, which compete directly with the fresh product and if freely imported would tend to make the restriction on the fresh product ineffective.

Paragraph 2, last sub-paragraph

The term "special factors" includes changes in relative productive efficiency as between domestic and foreign producers, or as between different foreign producers, but not changes artificially brought about by means not permitted under the Agreement.

Ad Article XVI

The exemption of an exported product from duties or taxes borne by the like product when destined for domestic consumption, or the remission of such duties or taxes in amounts not in excess of those which have accrued, shall not be deemed to be a subsidy.

Section B

1. Nothing in Section B shall preclude the use by a contracting party of multiple rates of exchange in accordance with the Articles of Agreement of the International Monetary Fund.

2. For the purposes of Section B, a "primary product" is understood to be any product of farm, forest or fishery, or any mineral, in its natural form or which has undergone such processing as is customarily required to prepare it for marketing in substantial volume in international trade.

Paragraph 3

1. The fact that a contracting party has not exported the product in question during the previous representative period would not in itself preclude that contracting party from establishing its right to obtain a share of the trade in the product concerned.

2. A system for the stabilization of the domestic price or of the return to domestic producers of a primary product independently of the movements of export prices, which results at times in the sale of the product for export at a price lower than the comparable price charged for the like product to buyers in the domestic market, shall be considered not to involve a subsidy on exports within the meaning of paragraph 3 if the CONTRACTING PARTIES determine that:

- (a) the system has also resulted, or is so designed as to result, in the sale of the product for export at a price higher than the comparable price charged for the like product to buyers in the domestic market; and
- (b) the system is so operated, or is designed so to operate, either because of the effective regulation of production or otherwise, as not to stimulate exports unduly or otherwise seriously to prejudice the interests of other contracting parties.

Notwithstanding such determination by the CONTRACTING PARTIES, operations under such a system shall be subject to the provisions of paragraph 3 where they are wholly or partly financed out of government funds in addition to the funds collected from producers in respect of the product concerned.

Paragraph 4

The intention of paragraph 4 is that the contracting parties should seek before the end of 1957 to reach agreement to abolish all remaining subsidies as from 1 January 1958; or, failing this, to reach agreement to extend the application of the standstill until the earliest date thereafter by which they can expect to reach such agreement.

Ad Article XVII

Paragraph 1

The operations of Marketing Boards, which are established by contracting parties and are engaged in purchasing or selling, are subject to the provisions of sub-paragraphs (a) and (b).

The activities of Marketing Boards which are established by contracting parties and which do not purchase or sell but lay down regulations covering private trade are governed by the relevant Articles of this Agreement.

The charging by a state enterprise of different prices for its sales of a product in different markets is not precluded by the provisions of this Article, provided that such different prices are charged for commercial reasons, to meet conditions of supply and demand in export markets.

Paragraph 1 (a)

Governmental measures imposed to ensure standards of quality and efficiency in the operation of external trade, or privileges granted for the exploitation of national natural resources but which do not empower the government to exercise control over the trading activities of the enterprise in question, do not constitute "exclusive or special privileges".

Paragraph 1 (b)

A country receiving a " tied loan " is free to take this loan into account as a " commercial consideration " when purchasing requirements abroad.

Paragraph 2

The term " goods " is limited to products as understood in commercial practice, and is not intended to include the purchase or sale of services.

Paragraph 3

Negotiations which contracting parties agree to conduct under this paragraph may be directed towards the reduction of duties and other charges on imports and exports or towards the conclusion of any other mutually satisfactory arrangement consistent with the provisions of this Agreement. (See paragraph 4 of Article II and the note to that paragraph.)

Paragraph 4 (b)

The term " import mark-up " in this paragraph shall represent the margin by which the price charged by the import monopoly for the imported product (exclusive of internal taxes within the purview of Article III, transportation, distribution, and other expenses incident to the purchase, sale or further processing, and a reasonable margin of profit) exceeds the landed cost.

Ad Article XX

Sub-paragraph (h)

The exception provided for in this sub-paragraph extends to any commodity agreement which conforms to the principles approved by the Economic and Social Council in its resolution 30 (IV) of 28 March 1947.

Ad Article XXVIII

The CONTRACTING PARTIES and each contracting party concerned should arrange to conduct the negotiations and consultations with the greatest possible secrecy in order to avoid premature disclosure of details of prospective tariff changes. The CONTRACTING PARTIES shall be informed immediately of all changes in national tariffs resulting from recourse to this Article.

Paragraph 1

1. If the CONTRACTING PARTIES specify a period other than a three-year period, a contracting party may act pursuant to paragraph 1 or paragraph 3 of

Article XXVIII on the first day following the expiration of such other period and, unless the CONTRACTING PARTIES have again specified another period, subsequent periods will be three-year periods following the expiration of such specified period.

2. The provision that on 1 January 1958, and on other days determined pursuant to paragraph 1, a contracting party "may . . . modify or withdraw a concession" means that on such day, and on the first day after the end of each period, the legal obligation of such contracting party under Article II is altered; it does not mean that the changes in its customs tariff should necessarily be made effective on that day. If a tariff change resulting from negotiations undertaken pursuant to this Article is delayed, the entry into force of any compensatory concessions may be similarly delayed.

3. Not earlier than six months, nor later than three months, prior to 1 January 1958, or to the termination date of any subsequent period, a contracting party wishing to modify or withdraw any concession embodied in the appropriate Schedule, should notify the CONTRACTING PARTIES to this effect. The CONTRACTING PARTIES shall then determine the contracting party or contracting parties with which the negotiations or consultations referred to in paragraph 1 shall take place. Any contracting party so determined shall participate in such negotiations or consultations with the applicant contracting party with the aim of reaching agreement before the end of the period. Any extension of the assured life of the Schedules shall relate to the Schedules as modified after such negotiations, in accordance with paragraphs 1, 2 and 3 of Article XXVIII. If the CONTRACTING PARTIES are arranging for multilateral tariff negotiations to take place within the period of six months before 1 January 1958, or before any other day determined pursuant to paragraph 1, they shall include in the arrangements for such negotiations suitable procedures for carrying out the negotiations referred to in this paragraph.

4. The object of providing for the participation in the negotiations of any contracting party with a principal supplying interest, in addition to any contracting party with which the concession was initially negotiated, is to ensure that a contracting party with a larger share in the trade affected by the concession than a contracting party with which the concession was initially negotiated shall have an effective opportunity to protect the contractual right which it enjoys under this Agreement. On the other hand, it is not intended that the scope of the negotiations should be such as to make negotiations and agreement under Article XXVIII unduly difficult nor to create complications in the application of this Article in the future to concessions which result from negotiations thereunder. Accordingly, the CONTRACTING PARTIES should only determine that a contracting party has a principal supplying interest if that contracting party has had, over a reasonable period of time prior to the negotiations, a larger share in the market of the applicant contracting party than a contracting party with which the concession was initially negotiated or would, in the judgment of the CONTRACTING PARTIES, have had such a share in the absence of discriminatory quantitative restrictions

maintained by the applicant contracting party. It would therefore not be appropriate for the CONTRACTING PARTIES to determine that more than one contracting party, or in those exceptional cases where there is near equality more than two contracting parties, had a principal supplying interest.

5. Notwithstanding the definition of a principal supplying interest in note 4 to paragraph 1, the CONTRACTING PARTIES may exceptionally determine that a contracting party has a principal supplying interest if the concession in question affects trade which constitutes a major part of the total exports of such contracting party.

6. It is not intended that provision for participation in the negotiations of any contracting party with a principal supplying interest, and for consultation with any contracting party having a substantial interest in the concession which the applicant contracting party is seeking to modify or withdraw, should have the effect that it should have to pay compensation or suffer retaliation greater than the withdrawal or modification sought, judged in the light of the conditions of trade at the time of the proposed withdrawal or modification, making allowance for any discriminatory quantitative restrictions maintained by the applicant contracting party.

7. The expression "substantial interest" is not capable of a precise definition and accordingly may present difficulties for the CONTRACTING PARTIES. It is, however, intended to be construed to cover only those contracting parties which have, or in the absence of discriminatory quantitative restrictions affecting their exports could reasonably be expected to have, a significant share in the market of the contracting party seeking to modify or withdraw the concession.

Paragraph 4

1. Any request for authorization to enter into negotiations shall be accompanied by all relevant statistical and other data. A decision on such request shall be made within thirty days of its submission.

2. It is recognized that to permit certain contracting parties, depending in large measure on a relatively small number of primary commodities and relying on the tariff as an important aid for furthering diversification of their economies or as an important source of revenue, normally to negotiate for the modification or withdrawal of concessions only under paragraph 1 of Article XXVIII, might cause them at such a time to make modifications or withdrawals which in the long run would prove unnecessary. To avoid such a situation the CONTRACTING PARTIES shall authorize any such contracting party, under paragraph 4, to enter into negotiations unless they consider this would result in, or contribute substantially towards, such an increase in tariff levels as to threaten the stability of the Schedules to this Agreement or lead to undue disturbance of international trade.

3. It is expected that negotiations authorized under paragraph 4 for modification or withdrawal of a single item, or a very small group of items, could normally be brought to a conclusion in sixty days. It is recognized, however, that such a period will be inadequate for cases involving negotiations for the modification or withdrawal of a larger number of items and in such cases, therefore, it would be appropriate for the CONTRACTING PARTIES to prescribe a longer period.

4. The determination referred to in paragraph 4 (*d*) shall be made by the CONTRACTING PARTIES within thirty days of the submission of the matter to them, unless the applicant contracting party agrees to a longer period.

5. In determining under paragraph 4 (*d*) whether an applicant contracting party has unreasonably failed to offer adequate compensation, it is understood that the CONTRACTING PARTIES will take due account of the special position of a contracting party which has bound a high proportion of its tariffs at very low rates of duty and to this extent has less scope than other contracting parties to make compensatory adjustment.

APPENDIX 2: SELECTED ARTICLES OF THE SUBSIDIES CODE

Article 8 Subsidies—General Provisions

1. Signatories recognize that subsidies are used by governments to promote important objectives of social and economic policy. Signatories also recognize that subsidies may cause adverse effects to the interests of other signatories.
2. Signatories agree not to use export subsidies in a manner inconsistent with the provisions of this Agreement.
3. Signatories further agree that they shall seek to avoid causing, through the use of any subsidy:
 - (a) injury to the domestic industry of another signatory;²³
 - (b) nullification or impairment of the benefits accruing directly or indirectly to another signatory under the General Agreement;²⁴ or
 - (c) serious prejudice to the interests of another signatory.²⁵
4. The adverse effects to the interests of another signatory required to demonstrate nullification or impairment²⁶ or serious prejudice may arise through
 - (a) the effects of the subsidized imports in the domestic market of the importing signatory,
 - (b) the effects of the subsidy in displacing or impeding the imports of like products into the market of the subsidizing country, or
 - (c) the effects of the subsidized exports in displacing²⁷ the exports of like products of another signatory from a third country market.²⁸

Article 9 Export Subsidies on Products Other Than Certain Primary Products²⁹

1. Signatories shall not grant export subsidies on products other than certain primary products.
2. The practices listed in points (a) to (1) in the Annex are illustrative of export subsidies.

Article 10 Export Subsidies on Certain Primary Products

1. In accordance with the provisions of Article XVI:3 of the General Agreement, signatories agree not to grant directly or indirectly any export subsidy on certain primary products in a manner which results in the signatory granting such subsidy having more than an equitable share of world export trade in such product, account being taken of the shares of the signatories in trade in the product concerned during a previous representative period, and any special factors which may have affected or may be affecting trade in such product.

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2. For purposes of Article XVI:3 of the General Agreement and paragraph 1 above:
 - (a) "more than equitable share of world export trade" shall include any case in which the effect of an export subsidy granted by a signatory is to displace the exports of another signatory bearing in mind the developments on world markets;
 - (b) with regard to new markets traditional patterns of supply of the product concerned to the world market, region or country, in which the new market is situated shall be taken into account in determining "equitable share of world export trade";
 - (c) "a previous representative period" shall normally be the three most recent calendar years in which normal market conditions existed.
3. Signatories further agree not to grant export subsidies on exports of certain primary products to a particular market in a manner which results in prices materially below those of other suppliers to the same market.

Article 11 Subsidies Other than Export Subsidies

1. Signatories recognize that subsidies other than export subsidies are widely used as important instruments for the promotion of social and economic policy objectives and do not intend to restrict the right of signatories to use such subsidies to achieve these and other important policy objectives which they consider desirable. Signatories note that among such objectives are:
 - (a) the elimination of industrial, economic and social disadvantages of specific regions,
 - (b) to facilitate the restructuring, under socially acceptable conditions, of certain sectors, especially where this has become necessary by reason of changes in trade and economic policies, including international agreements resulting in lower barriers to trade,
 - (c) generally to sustain employment and to encourage re-training and change in employment,
 - (d) to encourage research and development programmes, especially in the field of high-technology industries,
 - (e) the implementation of economic programmes and policies to promote the economic and social development of developing countries,
 - (f) redeployment of industry in order to avoid congestion and environmental problems.
2. Signatories recognize, however, that subsidies other than export subsidies, certain objectives and possible form of which are described, respectively, in paragraphs 1 and 3 of this Article, may cause or threaten to cause injury to a domestic industry of another signatory or serious prejudice to the interests of another signatory or may nullify or impair benefits accruing to another signatory under the General Agreement, in particular where such subsidies would adversely affect the conditions of normal competition. Signatories shall therefore seek to avoid causing such effects through the use of subsidies. In particular, signatories, when drawing up their policies and practices in this field, in addition to evaluating the essential internal objectives to be achieved, shall also weigh, as far as practicable, taking account of the nature of the particular case, possible adverse effects on trade. They shall also consider the conditions of world trade, production (e.g. price, capacity utilization etc.) and supply in the product concerned.

3. Signatories recognize that the objectives mentioned in paragraph 1 above may be achieved, *inter alia*, by means of subsidies granted with the aim of giving an advantage to certain enterprises. Examples of possible forms of such subsidies are: government financing of commercial enterprises, including grants, loans or guarantees; government provision or government financed provision of utility, supply distribution and other operational or support services or facilities; government financing of research and development programmes; fiscal incentives; and government subscription to, or provision of, equity capital.

Signatories note that the above form of subsidies are normally granted either regionally or by sector. The enumeration of forms of subsidies set out above is illustrative and non-exhaustive, and reflects these currently granted by a number of signatories to this Agreement.

Signatories recognize, nevertheless, that the enumeration of forms of subsidies set out above should be reviewed periodically and that this should be done, through consultations, in conformity with the spirit of Article XVI:5 of the General Agreement.

4. Signatories recognize further that, without prejudice to their rights under this Agreement, nothing in paragraphs 1-3 above and in particular the enumeration of forms of subsidies creates, in itself, any basis for action under the General Agreement, as interpreted by this Agreement.

Article 12 Consultations

1. Whenever a signatory has reason to believe that an export subsidy is being granted or maintained by another signatory in a manner inconsistent with the provisions of this Agreement, such signatory may request consultations with such other signatory.
2. A request for consultations under paragraph 1 above shall include a statement of available evidence with regard to the existence and nature of the subsidy in question.
3. Whenever a signatory has reason to believe that any subsidy is being granted or maintained by another signatory and that such subsidy either causes injury to its domestic industry, nullification or impairment of benefits accruing to it under the General Agreement, or serious prejudice to its interests, such signatory may request consultations with such other signatory.
4. A request for consultations under paragraph 3 above shall include a statement of available evidence with regard to (a) the existence and nature of the subsidy in question and (b) the injury caused to the domestic industry or, in the case of nullification or impairment, or serious prejudice, the adverse effects caused to the interests of the signatory requesting consultations.
5. Upon request for consultations under paragraph 1 or paragraph 3 above, the signatory believed to be granting or maintaining the subsidy practice in question shall enter into such consultations as quickly as possible. The purpose of the consultations shall be to clarify the facts of the situation and to arrive at a mutually acceptable solution.

Article 13 Conciliation, Dispute Settlement and Authorized Countermeasures

1. If, in the case of consultations under paragraph 1 of Article 12, a mutually acceptable solution has not been reached within thirty days¹⁰ of the request for consultations,

- any signatory party to such consultations may refer the matter to the Committee for conciliation in accordance with the provisions of Part VI.
2. If, in the case of consultations under paragraph 3 of Article 12, a mutually acceptable solution has not been reached within sixty days of the request for consultations, any signatory party to such consultations may refer the matter to the Committee for conciliation in accordance with the provisions of Part VI.
 3. If any dispute arising under this Agreement is not resolved as a result of consultations or conciliations, the Committee shall, upon request, review the matter in accordance with the dispute settlement procedures of Part VI.
 4. If, as a result of its review, the Committee concludes that an export subsidy is being granted in a manner inconsistent with the provisions of this Agreement or that a subsidy is being granted or maintained in such a manner as to cause injury, nullification or impairment, or serious prejudice, it shall make such recommendations³¹ to the parties as may be appropriate to resolve the issue and, in the event the recommendations are not followed, it may authorize such countermeasures as may be appropriate, taking into account the degree and nature of the adverse effects found to exist, in accordance with the relevant provisions of Part VI.

Notes

23. Injury to the domestic industry is used here in the same sense as it is used in Part I of this Agreement.
24. Benefits accruing directly or indirectly under the General Agreement include the benefits of tariff concessions bound under Article II of the General Agreement.
25. Serious prejudice to the interests of another signatory is used in this Agreement in the same sense as it is used in Article XVI:1 of the General Agreement and includes threat of serious prejudice.
26. Signatories recognize that nullification or impairment of benefits may also arise through the failure of a signatory to carry out its obligations under the General Agreement or this Agreement. Where such failure concerning export subsidies is determined by the Committee to exist, adverse effects may, without prejudice to paragraph 9 of Article 18 below, be presumed to exist. The other signatory will be accorded a reasonable opportunity to rebut this presumption.
27. The term "displacing" shall be interpreted in a manner which takes into account the trade and development needs of developing countries and in this connection is not intended to fix traditional market shares.
28. The problem of third country markets so far as certain primary products are concerned is dealt with exclusively under Article 10 below.
29. For purposes of this Agreement "certain primary products" means the products referred to in Note Ad Article XVI of the General Agreement, Section B, paragraph 2, with the deletion of the words "or any mineral."
30. Any time periods mentioned in this Article and in Article 18 may be extended by mutual agreement.
31. In making such recommendations, the Committee shall take into account the trade, development and financial needs of developing country signatories.

Annex Illustrative List of Export Subsidies

- (a) The provision by governments of direct subsidies to a firm or an industry contingent upon export performance.
- (b) Currency retention schemes or any similar practices which involve a bonus on exports.
- (c) Internal transport and freight charges on export shipments, provided or mandated by governments, on terms more favourable than for domestic shipments.
- (d) The delivery by governments or their agencies of imported or domestic products or services for use in the production of exported goods, on terms or conditions more favourable than for delivery of like or directly competitive products or services for use in the production of goods for domestic consumption, if (in the case of products) such terms or conditions are more favourable than those commercially available on world markets to their exporters.
- (e) The full or partial exemption, remission, or deferral specifically related to exports, of direct taxes¹ or social welfare charges paid or payable by industrial or commercial enterprises.²
- (f) The allowance of special deductions directly related to exports or export performance, over and above those granted in respect to production for domestic consumption, in the calculation of the base on which direct taxes are charged.
- (g) The exemption or remission in respect of the production and distribution of exported products, of indirect taxes¹ in excess of those levied in respect of the production and distribution of like products when sold for domestic consumption.
- (h) The exemption, remission or deferral of prior stage cumulative indirect taxes¹ on goods or services used in the production of exported products in excess of the exemption, remission or deferral of like prior stage cumulative indirect taxes on goods or services used in the production of like products when sold for domestic consumption; provided, however, that prior stage cumulative indirect taxes may be exempted, remitted or deferred on exported products even when not exempted, remitted or deferred on like products when sold for domestic consumption, if the prior stage cumulative indirect taxes are levied on goods that are physically incorporated (making normal allowance for waste) in the exported product.³
- (i) The remission or drawback of import charges¹ in excess of those levied on imported goods that are physically incorporated (making normal allowance for waste) in the exported product; provided, however, that in particular cases a firm may use a quantity of home market goods equal to, and having the same quality and characteristics as, the imported goods as a substitute for them in order to benefit from this provision if the import and the corresponding export operations both occur within a reasonable time period, normally not to exceed two years.
- (j) The provision by governments (or special institutions controlled by governments) of export credit guarantees or insurance programmes, of insurance or guarantee programmes against increases in the costs of exported products⁴ or of exchange risk programmes, at premium rates, which are manifestly inadequate to cover the long-term operating costs and losses of the programmes.⁵
- (k) The grant by governments (or special institutions controlled by and/or acting under the authority of governments) of export credits at rates below those which they actually have to pay for the funds so employed (or would have to pay if they borrowed on international capital markets in order to obtain funds of the same maturity and

denominated in the same currency as the export credit), or the payment by them of all or part of the costs incurred by exporters or financial institutions in obtaining credits, in so far as they are used to secure a material advantage in the field of export credit terms.

Provided, however, that if a signatory is a party to an international undertaking on official export credits to which at least twelve original signatories⁶ to this Agreement are parties as of 1 January 1979 (or a successor undertaking which has been adopted by those original signatories), or if in practice a signatory applies the interest rates provisions of the relevant undertaking, an export credit practice which is in conformity with those provisions shall not be considered an export subsidy prohibited by this Agreement.

- (l) Any other charge on the public account constituting an export subsidy in the sense of Article XVI of the General Agreement.

Notes

1. For the purpose of this Agreement:

The term "direct taxes" shall mean taxes on wages, profits, interest, rents, royalties, and all other forms of income, and taxes on the ownership of real property;

The term "import charges" shall mean tariffs, duties, and other fiscal charges not elsewhere enumerated in this note that are levied on imports;

The term "indirect taxes" shall mean sales, excise, turnover, value added, franchise, stamp, transfer, inventory and equipment taxes, border taxes and all taxes other than direct taxes and import charges;

"Prior stage" indirect taxes are those levied on goods or services used directly or indirectly in making the product;

"Cumulative" indirect taxes are multi-staged taxes levied where there is no mechanism for subsequent crediting of the tax if the goods or services subject to tax at one stage of the production are used in a succeeding stage of production;

"Remission" of taxes includes the refund or rebate of taxes.

2. The signatories recognize that deferral need not amount to an export subsidy where, for example, appropriate interest charges are collected. The signatories further recognize that nothing in this text prejudices the disposition by the CONTRACTING PARTIES of the specific issues raised in GATT document L/4422. The signatories reaffirm the principle that prices for goods in transactions between exporting enterprises and foreign buyers under their or under the same control should for tax purposes be the prices which would be charged between independent enterprises acting at arm's length. Any signatory may draw the attention of another signatory to administrative or other practices which may contravene this principle and which result in a significant saving of direct taxes in export transactions. In such circumstances the signatories shall normally attempt to resolve their differences using the facilities of existing bilateral tax treaties or other specific international mechanisms, without prejudice to the rights and obligations of signatories under the General Agreement, including the right of consultation created in the preceding sentence.

Paragraph (e) is not intended to limit a signatory from taking measures to avoid the double taxation of foreign source income earned by its enterprises of the enterprises of another signatory.

Where measures incompatible with the provisions of paragraph (e) exist, and where major practical difficulties stand in the way of the signatory concerned bringing such measures promptly into conformity with the Agreement, the signatory concerned shall, without prejudice to the rights of other signatories under the General Agreement or this Agreement, examine methods of bringing these measures into conformity within a reasonable period of time.

In this connexion the European Economic Community has declared that Ireland intends to withdraw by 1 January 1981 its system of preferential tax measures related to exports, provided for under the Corporation Tax Act of 1976, whilst continuing nevertheless to honour legally binding commitments entered into during the lifetime of this system.

3. Paragraph (h) does not apply to value-added tax systems and border-tax adjustment in lieu thereof; the problem of the excessive remission of value-added taxes is exclusively covered by paragraph (g).

4. The signatories agree that nothing in this paragraph shall prejudice or influence the deliberations of the panel established by the GATT Council on 6 June 1978 (C/M/126).

5. In evaluating the long-term adequacy of premium rates, costs and losses of insurance programmes, in principle only such contracts shall be taken into account that were concluded after the date of entry into force of this Agreement.

6. An original signatory to this Agreement shall mean any signatory which adheres *ad referendum* to the Agreement on or before 30 June 1979.

APPENDIX 3: MINISTERIAL DECLARATION ON THE URUGUAY ROUND

PART I

NEGOTIATIONS ON TRADE IN GOODS

...

A. OBJECTIVES

Negotiations shall aim to:

- (i) bring about further liberalization and expansion of world trade to the benefit of all countries, especially less-developed contracting parties, including the improvement of access to markets by the reduction and elimination of tariffs, quantitative restrictions and other non-tariff measures and obstacles;
 - (ii) strengthen the role of GATT, improve the multilateral trading system based on the principles and rules of the GATT and bring about a wider coverage of world trade under agreed, effective and enforceable multilateral disciplines;
- ...

B. GENERAL PRINCIPLES GOVERNING NEGOTIATIONS

- (i) Negotiations shall be conducted in a transparent manner, and consistent with the objectives and commitments agreed in this Declaration and with the principles of the General Agreement in order to ensure mutual advantage and increased benefits to all participants.
- (ii) The launching, the conduct and the implementation of the outcome of the Negotiations shall be treated as parts of a single undertaking. However, agreements reached at an early stage may be implemented on a provisional or a definitive basis by agreement prior to the formal conclusion of the Negotiations. Early agreements shall be taken into account in assessing the overall balance of the negotiations.
- (iii) Balanced concessions should be sought within broad trading areas and subjects to be negotiated in order to avoid unwarranted cross-sectoral demands.

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- (iv) CONTRACTING PARTIES agree that the principle of differential and more favorable treatment embodied in Part IV and other relevant provisions of the General Agreement and in the Decision of the CONTRACTING PARTIES of 28 November 1979 on Differential and More Favourable Treatment, Reciprocity and Fuller Participation of Developing Countries applies to the negotiations. In the implementation of standstill and rollback, particular care should be given to avoiding disruptive effects on the trade of less-developed contracting parties.
- (v) The developed countries do not expect reciprocity for commitments made by them in trade negotiations to reduce or remove tariffs and other barriers to the trade of developing countries, i.e., the developed countries do not expect the developing countries, in the course of trade negotiations, to make contributions which are inconsistent with their individual development, financial and trade needs. Developed contracting parties shall therefore not seek, neither shall less-developed contracting parties be required to make, concessions that are inconsistent with the latter's development, financial and trade needs.
- (vi) Less-developed contracting parties expect that their capacity to make contributions or negotiated concessions or take other mutually agreed action under the provisions and procedures of the General Agreement would improve with the progressive development of their economies and improvement in their trade situation and they would accordingly expect to participate more fully in the framework of rights and obligations under the General Agreement.
- (vii) Special attention shall be given to the particular situation and problems of the least-developed countries and to the need to encourage positive measures to facilitate expansion of their trading opportunities. Expedient implementation of the relevant provisions of the 1982 Ministerial Declaration concerning the least-developed countries shall also be given appropriate attention.

C. STANDSTILL AND ROLLBACK

Commencing immediately and continuing until the formal completion of the Negotiations, each participant agrees to apply the following commitments:

Standstill

- (i) not to take any trade restrictive or distorting measure inconsistent with the provisions of the General Agreement or the Instruments negotiated within the framework of GATT or under its auspices;
- (ii) not to take any trade restrictive or distorting measure in the legitimate exercise of its GATT rights, that would go beyond that which is necessary to remedy specific situations, as provided for in the General Agreement and the Instruments referred to in (i) above;

- (iii) not to take any trade measures in such a manner as to improve its negotiating positions.

Rollback

- (i) that all trade restrictive or distorting measures inconsistent with the provisions of the General Agreement or instruments negotiated within the framework of GATT or under its auspices, shall be phased out or brought into conformity within an agreed time frame not later than by the date of the formal completion of the negotiations, taking into account multi-lateral agreements, undertakings and understandings, including strengthened rules and disciplines, reached in pursuance of the Objectives of the Negotiations;

...

D. SUBJECTS FOR NEGOTIATIONS

Tariffs

Negotiations shall aim, by appropriate methods, to reduce or, as appropriate, eliminate tariffs including the reduction or elimination of high tariffs and tariff escalation. Emphasis shall be given to the expansion of the scope of tariff concessions among all participants.

Non-tariff Measures

Negotiations shall aim to reduce or eliminate non-tariff measures, including quantitative restrictions, without prejudice to any action to be taken in fulfillment of the rollback commitments.

Tropical Products

Negotiations shall aim at the fullest liberalization of trade in tropical products, including in their processed and semi-processed forms and shall cover both tariff and all non-tariff measures affecting trade in these products.

...

Natural Resource-Based Products

...

Textiles and Clothing

...

Agriculture

CONTRACTING PARTIES agree that there is an urgent need to bring more discipline and predictability to world agricultural trade by correcting and preventing restrictions and distortions including those related to structural surpluses so as to reduce the uncertainty, imbalances and instability in world agricultural markets.

Negotiations shall aim to achieve greater liberalization of trade in agriculture and bring all measures affecting import access and export competition under strengthened and more operationally effective GATT rules and disciplines, taking into account the general principles governing the negotiations, by:

- (i) improving market access through, *inter alia*, the reduction of import barriers;
- (ii) improving the competitive environment by increasing discipline on the use of all direct and indirect subsidies and other measures affecting directly or indirectly the phased reduction of their negative effects and dealing with their causes;
- (iii) minimizing the adverse effects that sanitary and phytosanitary regulations and barriers can have on trade in agriculture, taking into account the relevant international agreements.

In order to achieve the above objectives, the negotiating group having responsibility for all aspects of agriculture will use the recommendations adopted by the CONTRACTING PARTIES at their Fortieth Session, which were developed in accordance with the GATT 1982 Ministerial Programme and take account of the approaches suggested in the work of the Committee on Trade in Agriculture without prejudice to other alternatives that might achieve the objectives of the Negotiations.

GATT Articles

Participants shall review existing GATT articles, provisions and disciplines as requested by interested contracting parties, and, as appropriate, undertake negotiations.

Safeguards

- (i) A comprehensive agreement on safeguards is of particular importance to the strengthening of the GATT system and to progress in the MTNs.
- (ii) The agreement on safeguards:
 - shall be based on the basic principles of the General Agreement;
 - shall contain, *inter alia*, the following elements: transparency, coverage, objective criteria for action including the concept of serious injury or threat thereof, temporary nature, degressivity and structural adjustment, compensation and retaliation, notifications, consultation, multi-lateral surveillance and dispute settlement; and
 - shall clarify and reinforce the disciplines of the General Agreement and should apply to all contracting parties.

MTN Agreements and Arrangements

Negotiations shall aim to improve, clarify, or expand, as appropriate, agreements and arrangements negotiated in the Tokyo Round of Multilateral Negotiations.

Subsidies and Countervailing Measures

Negotiations on subsidies and countervailing measures shall be based on a review of Articles VI and XVI and the MTN agreement on subsidies and countervailing measures with the objective of improving GATT disciplines relating to

all subsidies and countervailing measures that affect international trade. A negotiating group will be established to deal with these issues.

Dispute Settlement

In order to ensure prompt and effective resolution of disputes to the benefit of all contracting parties, negotiations shall aim to improve and strengthen the rules and the procedures of the dispute settlement process, while recognizing the contribution that would be made by more effective and enforceable GATT rules and disciplines. Negotiations shall include the development of adequate arrangements for overseeing and monitoring of the procedures that would facilitate compliance with adopted recommendations.

Trade Related Aspects of Intellectual Property Rights, including Trade in Counterfeit Goods

...

Trade-Related Investment Measures

...

E. FUNCTIONING OF THE GATT SYSTEM

Negotiations shall aim to develop understandings and arrangements:

- (i) to enhance the surveillance in the GATT to enable regular monitoring of trade policies and practices of contracting parties and their impact on the functioning of the multilateral trading system;
- (ii) to improve the overall effectiveness and decision-making of the GATT as an institution, including, *inter alia*, through involvements of ministers;
- (iii) to increase the contribution of the GATT to achieving greater coherence in global economic policy-making through strengthening its relationship with other international organizations responsible for monetary and financial matters.

F. PARTICIPATION

...

G. ORGANIZATION OF THE NEGOTIATIONS

A Group of Negotiations on Goods (GNG) is established to carry out the programme of negotiations contained in this part of the Declaration. The GNG shall, *inter alia*:

...

- (iii) establish negotiating groups as required. . . .
- (v) coordinate the work of the negotiating groups and supervise the progress of the negotiations. As a guideline, not more than two negotiating groups should meet at the same time;

...

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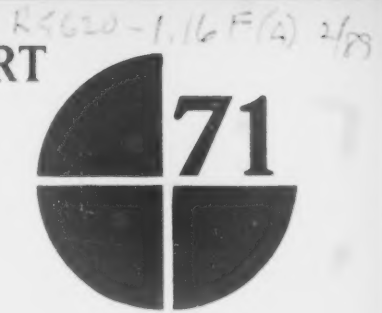
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RESEARCH REPORT



STORAGE, TRADE, AND PRICE POLICY UNDER PRODUCTION INSTABILITY: MAIZE IN KENYA

Thomas C. Pinckney

December 1988

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**STORAGE, TRADE, AND PRICE
POLICY UNDER PRODUCTION
INSTABILITY: MAIZE IN KENYA**

Thomas C. Pinckney

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FOREWORD

Instability in the production of a staple food causes severe hardship for many countries. For a country that is self-sufficient in its staple food in a normal production year, the large swings in price and consumption that result from an exclusive and uninhibited reliance on trade to stabilize prices are unacceptable. Most countries, therefore, intervene in their domestic cereal markets and move supplies from surplus to deficit years through storage or by subsidizing international trade. The appropriate method of intervention and the most efficient way to achieve supply stability thus become topics of study. For the most part, economists have encouraged governments to rely more on trade than on stocks to make up deficits in years of production shortfalls.

Trade becomes less appealing as an option the larger the difference between import and export parity prices, and the greater the deviation in physical characteristics between the domestically consumed commodity and the imported commodity. Storage is more likely to be appropriate for African countries, since many of them have high transport costs and consume a commodity—white maize—that is often in short supply on world markets.

The International Food Policy Research Institute has examined these issues previously in books and research reports. *Food Security for Developing Countries*, edited by Alberto Valdés, discusses these issues in some detail. *International Finance for Food Security*, edited by Barbara Huddleston et al., is a study of ways that the international community can remove some of the risks of relying on trade rather than stocks. In IFPRI Research Report 26, *Food Security in the Sahel: Variable Import Levy, Grain Reserves, and Foreign Exchange Assistance*, John McIntire examines various policy options for dealing with instability in the Sahelian region.

In this report, Thomas Pinckney develops a general framework for studying these issues and applies it to the case of Kenya. The framework builds both on the optimal storage literature and on simulation studies. Trade-offs between the government objectives of minimizing price fluctuations, imports, and fiscal costs are measured explicitly. The techniques that make the optimal policies superior to simpler price band/buffer stock policies are studied in order to provide clues for efficient policy design. In terms of the storage/trade debate, this report finds that Kenya does indeed have a strong rationale for a significant amount of storage when world maize prices are at their present low levels.

Techniques developed in this research report have been modified and applied to Pakistan and will be applied to several southern African countries in the future. This will provide the coherent set of studies required to make generalizations about these important questions.

John W. Mellor

Washington, D.C.
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This study was undertaken in several different stages through the support of a number of different persons and organizations. Consequently, my debts are even greater than those usually incurred by authors.

The study began in 1983 as one part of an interministerial report on grain marketing. John Cohen of the Harvard Institute for International Development had been responsible for hiring a raw graduate student 18 months earlier, and Dick Goldman named me to the study team for the report. Dick has been a good friend and stimulating colleague ever since; many thanks are due him.

Following my departure from Kenya, the report took on a semblance of its present shape when it was transformed into my doctoral dissertation at Stanford's Food Research Institute. HIID provided funding for part of my support during the writing period. My dissertation committee was helpful throughout, particularly Carl Gotsch, the chairman. Carl also was primarily responsible for producing an article based on the dissertation, "Simulation and Optimization of Price Stabilization Policies: Maize in Kenya," which appeared in *Food Research Institute Studies* 20:3.

After I came to the International Food Policy Research Institute to work on a similar study of Pakistan, Alberto Valdés encouraged me to revise my thesis for submission as an IFPRI Research Report. Chris Delgado, Marc Nerlove, Uma Lele, and an anonymous reviewer provided helpful comments.

SUMMARY

Kenya has been faced with the problem of production instability for as long as records have been kept. Over the last 10-year period, the country has produced about the same amount of its staple food, white maize, as it has consumed. During normal weather years, private markets have cleared at prices that are between import parity and export parity. Yet the country faced severe shortages in 1980 and 1984, and in early 1987 was faced with the opposite problem of a large excess supply. The strategy the government pursues in managing these fluctuations in supply has important ramifications for the government budget and the government's political support.

For most of the period since independence, Kenya's stated policy in this regard has been simple: all maize that is not sold directly from a producer to a consumer is to be sold to a parastatal marketing board, the National Cereals and Produce Board (NCPB). The NCPB is instructed to buy all the maize that it is offered at a price set by the government, and to sell all the maize that is demanded at a higher price, also set by the government. Since the government purchase price is set before planting, there is no sensitivity to the size of the crop. By law, therefore, there is to be no fluctuation in producer prices.

In reality, both consumers and producers have faced large fluctuations in prices. The government has not given the NCPB the fiscal resources necessary to fulfill its mandate. The NCPB has responded in surplus years by delaying payments to farmers, forcing prospective sellers to wait in long lines, and rejecting many lots in the name of quality control. In deficit years, millers have not been able to buy as much as they desire at the set price. The result has been the dependence of a large percentage of farmers and consumers on the parallel informal market and large fluctuations in price on that market.

This policy has been increasingly difficult for the government to pursue, as fiscal austerity has been recognized as vital to Kenya's long-term development. Thus a systematic analysis of policies for countering production instability is in order; in particular, it is important that the analysis be conducted from the government's perspective by measuring trade-offs between different government objectives.

The three objectives considered here are minimizing price fluctuations, minimizing fiscal cost, and minimizing imports. Minimizing imports is a separate goal over and above the cost involved for two reasons: first, imported maize is yellow, while locally grown maize is white; second, most Kenyans believe that their country should be self-sufficient in its staple food.

A common policy prescription from earlier studies is for the NCPB to defend floor and ceiling prices for maize rather than to engage in primary marketing. This policy option, with foreign trade triggered by the stock level, is termed a "price band policy" here. Price band policies with different band widths and stock triggers are simulated in this study in order to examine their effects on the three government objectives. This allows for the measurement of trade-offs between objectives.

These estimates of trade-offs will be accurate if the price band policies are efficient. There are theoretical reasons, however, for believing that such policies are inefficient. To obtain accurate estimates of the trade-offs, Kenya's storage and trade problems are solved using a model that produces the best values for domestic purchases and sales,

foreign trade, and domestic stocks, given any particular system of government preferences for the three objectives. The optimization method used, stochastic dynamic programming, guarantees that the estimates of trade-offs between objectives are accurate, since the most efficient policy has been chosen.

A simple model is developed with random production fluctuations and random movements in the world price of maize. The government responds by purchasing and selling maize both domestically and internationally and storing the result of those transactions. Because the most efficient policy will depend on how much the government values, say, price stability vis-à-vis fiscal cost, the optimization exercise is carried out with several different weightings of the three government objectives. Price band policies with different-width price bands and different stock triggers for international trade are tested also.

For the same level of imports and price stability, the policies that come out of the optimization procedure cost about US\$1.5 million less annually than the price band policies. These cost savings result primarily from increased flexibility. In the optimal policies, the domestic price is sensitive to the world price, domestic production, and the government's opening stock, while the maximum stock level (which triggers exports) is sensitive to the world price.

Trade-offs between fiscal cost and price stability as measured by the price band policies are found to be lower than the true trade-offs. As measured by the optimal policies, the average annual cost of decreasing the standard deviation of price by \$1.00 per metric ton is \$400,000-\$600,000 annually, with the larger values occurring as the standard deviation moves towards zero. On the other hand, the price band policies overestimate the cost of decreasing imports. The correct trade-off is \$60,000-\$130,000 annually per 1,000-ton decrease in average annual imports, with the higher values occurring as average annual imports decline.

Despite the advantages of the policies that are produced by the optimization procedure, it would be incorrect to recommend that the government adopt such rules for several reasons. Most important, the optimal policies are much more complex than the price band policies. The government has an objective of designing relatively simple policies, but this objective is not easily built into an optimizing model. There is thus a trade-off between the cost of a policy and its complexity.

The lessons learned about optimal policy design are introduced into the price band policy one by one in order to design a policy that is efficient, yet retains the desirable simplicity of the price band policy. About two-thirds of the difference between the optimal and price band policies can be made up by allowing the domestic price to be sensitive to the world price and opening stocks and by making the maximum stock level sensitive to the world price. Further efficiency gains can only be made by allowing the crop size to influence the official domestic price.

Three major policy conclusions are made. First, there is no one optimal stock level, but the most appropriate closing stock level in any one year is a function of the opening stock level, production, and the world price. Second, by adding some flexibility to official prices, significant cost savings could be incurred, which would make it more likely that the NCPB would be given sufficient fiscal resources to defend the official price. Thus, price instability faced by Kenyan producers and consumers could actually decrease even though official prices would not be totally stable. Third, the degree of price flexibility required to achieve significant cost savings is not large, as shown by the trade-off between fiscal cost and price stability.

INTRODUCTION

In the 1981/82 crop year, Kenya produced approximately 2.5 million metric tons¹ of its staple crop, white maize. This bumper crop, which was 20 percent higher than the previous record, caused serious financial problems for the country's grain-marketing parastatal, the National Cereals and Produce Board (NCPB). The board was unable to pay farmers for their crop on delivery. In some cases depot managers simply refused to buy more maize; in others, farmers were forced to wait as long as nine months for payment. NCPB stores were full of maize and beans, with substantial quantities stored outside under tarpaulins. For a country that had experienced a fairly severe food crisis only two years before and had been labeled a chronic maize importer by many "experts," the experience was both relieving and terribly costly. With memories of queues for maize in Nairobi still fresh in everyone's mind, the government was reluctant to approve exports when imports might be required in the near future. Yet the country was in the middle of a financial crisis, with foreign reserves at their lowest point ever.

Rather belatedly, the cabinet decided to allow the NCPB to export maize during 1983 and 1984 after two reasonably good crop years. Over 100,000 tons were exported in January and February 1984. During April and May of that year, however, the government's worst fears were realized: not only were the rains in semiarid Eastern Province low for the third year in a row, but the normally reliable rains in parts of the Rift Valley were only 50 percent of normal. Failure of the rains in this breadbasket of the country led to a severe national shortage in addition to the anticipated purchasing-power problem in the east.

From the very beginning of the crisis, debate raged in the press about the maize that had been exported in January and February 1984. Unnamed officials were accused of corruption while the populace waited in queues for any white maize that became available. For about two weeks in August 1984 there was no maize meal to buy in Nairobi shops, despite assurances from the government about the adequacy of maize supplies in the country. The supply situation for maize in the rural areas was even more erratic. The failure of the bean and potato crops took away two of the most important alternative sources of calories in Central and Eastern provinces.

The government was reluctant to take the logical step of importing maize. Imports present Kenya with a threefold problem. First, the NCPB selling price of maize is determined in advance and in 1984/85 was between the import and export parity prices. As Kenya was exporting maize at planting time, this price was reasonable. But if the country was to maintain its tradition of holding official prices constant, the government would suffer large losses on every ton of imported maize sold domestically, even without correcting for Kenya's marginally overvalued exchange rate. Second, there is a strong feeling in the country that Kenya can and should be self-sufficient in maize. Imports are normally interpreted as a policy failure, and this would be especially true in 1984, since the country had exported in the first two months of the year. Indeed, a December 1984 review of the year's events in the local press was entitled

¹ All tons referred to in this report are metric tons.

"Disturbing Year: Drought, Inefficiency, and Lack of Foresight Lead to Hunger."² Third, Kenyans produce and consume white maize, and virtually all of the maize on the international market is yellow. When there is sufficient rain in southern Africa, South Africa exports a significant amount of white maize, but there are obvious problems for a black African country in buying that maize. Thus Kenya imports yellow maize, which looks and tastes different from the local product. The country's citizens are reminded every time they sit down to eat that their government has failed to meet one of its most important goals. Obviously, government decisionmakers want to avoid all three of these problems.

Throughout the first half of 1984 the official price remained constant. Local markets, on the other hand, began to react earlier to the low rainfall. With local market prices higher than the NCPB selling price, demand for NCPB maize increased dramatically. In May the NCPB had net sales of almost 90,000 tons, breaking the previous one-month record (of July 1980) by almost 40 percent. From May to July, NCPB net sales were about 306,000 tons, breaking the previous three-month record by an extraordinary 80 percent. The government's stockpile was being depleted rapidly.

By early July the government had realized that its stock position was untenable and reluctantly arranged for imports. Several development projects were delayed or curtailed because of the expected cost of the import program, which would eventually bring in almost 1 million tons during 1984/85. The administrative costs were also high, as key decisionmakers in the government spent large blocks of time trying to manage the problem.

The problems presented above are not new. Indeed, one of the most interesting descriptions of the issues still facing the Kenyan government was written by a Maize Commission of Inquiry more than 20 years ago (Kenya 1966):

The dominant feature in the price structure for maize is the wide differential between the import parity and export parity prices. . . . The sharp fluctuations in the annual supply, and the inflexible total consumer demand mean . . . that it is virtually impossible to plan production exactly to meet domestic demand, even allowing for the holding of an unduly large and costly domestic reserve stock, without incurring the need to export or import at a loss from time to time. . . . It is against this cost and price background that the Government has to determine the appropriate organization for handling maize, and to fix prices to the producer, the miller, the distributor, and the consumer.

The report recognizes the fundamental problem of production variability and the costs associated with depending on storage or trade alone to deal with the problem, while accepting without comment the government's desire to mandate prices at each stage of the marketing chain. Twenty years later the government is trying to manage the same problem in an ad hoc way as each crisis comes along. Considering the Maize Commission of Inquiry report and other studies conducted during the last 60 years, Maratim (1982) laments:

Since the first documented maize crisis of 1918, periodic maize shortages have provoked thirteen commissions of inquiry, working parties or select committees to investigate and make recommendations on the pricing and marketing of maize in the country. Most of these investigations have conducted expert analysis and made responsible recommendations only to see maize policy continue to be made on an ad hoc basis, with the authorities acting too late to avert the immediate crisis and then taking little remedial action until the next crisis.

² *Weekly Review* (Nairobi), December 21, 1984.

There is hope that this situation is changing. Until the 1980s, maize marketing was not a major component of government cost. The studies and commissions of inquiry were conducted after each crisis, but as the situation returned to normal the politicians felt less inclined to make the sort of difficult decisions necessary for a major change in maize marketing. During this decade, however, the situation has never returned to "normal." Between 1979 and 1984 the NCPB consumed from 10 to 20 percent of the total amount spent by the Ministry of Agriculture and Livestock Development.³ This is in contrast to the early 1970s, when the board was virtually breaking even. With NCPB costs continuing to consume a larger and larger proportion of the country's agricultural sector investment, there is a much broader constituency for reforming maize marketing than at any time in the past.

NCPB losses began to increase at the same time that the difference between government expenditures and revenues began to grow to disturbing proportions. High coffee prices in the late 1970s had increased government revenues substantially, and as a consequence fiscal discipline in the government became lax (Pinckney, Cohen, and Leonard 1982; Leonard, Cohen, and Pinckney 1983). The size of the budget deficit prompted the president to appoint a Working Party on Government Expenditures in 1982 to study the problem. The report of the working party (Kenya 1982) states that

Not to reduce the gap between revenue and expenditure would entail expansionary fiscal and monetary policies and creation of excessive domestic credit. This path would aggravate rather than ameliorate the economic circumstances facing the nation. . . It is not enough, however, merely to curtail Government expenditure, that is, 'to cut our coat according to the size of our cloth.' While Government expenditure must be contained within feasible limits, the development of the nation must continue. . . . As a consequence, Government must in the years ahead . . . allocate its expenditures according to orderly priorities.

The budget deficit has led to an emphasis on sorting out government priorities in different areas of public policy. The growing importance of the subvention to the NCPB as a proportion of total funds spent on the agricultural sector highlights maize marketing as one important area where priorities need to be examined. Add to these internal pressures the interest of major donors in reform, and it would appear likely that within the next few years some changes will be made in maize-marketing policy. Given this possible "window of opportunity," a systematic analysis of methods to deal with the problem is in order; in particular, it is important that an analysis be conducted from the government's perspective, measuring trade-offs between different government priorities.

This study, then, examines trade, stockholding, and pricing strategies that can be used to deal with production instability in Kenya. The primary goal of the analysis is to measure the trade-offs between three government objectives: minimizing price fluctuations, minimizing fiscal costs, and minimizing imports. The last two goals are clear and have been described above; the first requires further elaboration.

Price stability as it is used here measures average annual deviations from a target real price. The government wants farmers to be assured of a reasonable price and wants consumers to be satisfied with the price and quantity available. The history of price control dates back to the Second World War and is deeply ingrained in the political preferences of the government. This is more clearly seen by what the government has

³ Richard Goldman, personal communication, October 1985.

not done than by any action or statement. Despite large losses on every ton of maize that was imported and sold domestically in 1980/81 and 1984/85, the government official price remained firm. Similarly, in 1981/82 when buying the bumper crop caused the NCPB to run out of cash, official prices did not decrease. Reports such as the one by the 1966 Maize Commission of Inquiry that was quoted above accept this government goal without comment.⁴

This study will attempt to measure the trade-offs between this price stability goal and the fiscal and self-sufficiency goals in order to measure the cost of stabilizing prices. At the outset, however, it is important to note that the study is dealing with questions of annual, national supply, and not with regional or seasonal shortages. This choice of objective does not imply that fluctuations in food supply by season or within provinces, districts, villages, or households are less important.⁵ Nor does the choice of objective imply that food crises can be averted simply by ensuring adequate levels of national supply. As Sen (1981) has pointed out, famines often are associated more closely with the loss of purchasing power by large segments of the population than with supply fluctuations alone. Nevertheless, ensuring adequate national supply is a necessary, albeit not sufficient, condition for averting famine, and questions related to this issue are to a large extent separable from regional and seasonal factors. In addition, as the brief history above illustrates, a country like Kenya needs to examine maize pricing, stockholding, and trading strategies that will provide guidelines for action in exceptionally good years and normal years, not only in years of shortfall. The following brief review of the policy context points out that the government has not in fact been meeting its price stability goal despite high fiscal expenditures.

By law, the government has complete control of the marketing system in the country, with the NCPB acting as its agent.⁶ Before planting each year, the government announces the price at which it will buy maize at harvest time.⁷ The government also calculates corresponding selling prices at each level of the marketing chain, including the retail price of a 2-kilogram packet of sifted meal, but these selling prices usually are not made final until a later date. They are announced and take immediate effect close to the beginning of the first harvest. The NCPB is supposed to purchase all of the maize that it is offered at its buying price and to supply all that millers and agents want to purchase at its selling price. All foreign trade is handled by the board, but trade decisions are made by the cabinet, not the NCPB.

Most transactions other than those involving the board at the chosen price are illegal. Farmers may legally sell maize to persons whose families will consume it directly, but may not sell to traders or to institutions. All other sales are supposed to be handled by the NCPB. In fact, the government allows trade in rural markets within districts, although in most years large millers are required to buy from the board.

Restrictions on the movement of maize are enforced much more rigorously than restrictions on sales. Moving more than two bags of maize requires a permit, and the

⁴ This study argues that price stability *is* a goal of the Kenyan government, and consequently it is included in the government objective function. There has been considerable discussion in the welfare economics literature concerning whether or not price stability *should be* a goal of the government. The seminal articles in this literature are Waugh 1945; Oi 1961; Massell 1969; Samuelson 1972; and Turnovsky 1978.

⁵ For a recent paper on seasonal and regional shortages, see Kleist 1985.

⁶ Kenya's agricultural sector is neither described nor analyzed here. The best study is still Heyer, Maitha, and Senga 1976. For a much more complete review of the maize marketing system than the one presented here, see Booker International 1983.

⁷ See Jabara 1984 for a description of the price review process.

police are likely to interfere with persons carrying even one bag (Booker International 1983, 9). Carrying any maize across district boundaries requires a permit, and permits for large amounts are issued only rarely. Unquestionably, some illegal private movement of maize takes place in the country, but recent market price data indicate that the amounts being shipped long distances are not sufficient to arbitrage price differentials. As shown in Table 1, in September of 1984, during a good harvest in Western and Nyanza provinces and a period of very short supply in Eastern and Central provinces, local market prices for maize in Eastern and Central were two to three times as high as they were in the west. In some cases, the differences were over \$200 per ton,⁸ which is much higher than the transportation costs.

If the board actually functioned in the way the law is written, these private market prices would not vary much more than the difference between NCPB buying and selling prices, even in times such as September 1984. The market would have a competitor in the NCPB, but the government has not given the board the fiscal resources necessary to accomplish this task. The NCPB has responded by not buying all the maize available in bumper crop years and by selling less than market demand in scarce years. Goldman (1983) has shown econometrically that the NCPB's buying and selling behavior is influenced by its available stocks. Private market prices such as those in Table 1 confirm this analysis.

These conclusions are reinforced by several studies of the marketing system in Kenya. Schmidt (1979, 65) found that in times of plenty the board forced prospective sellers to line up for days before taking delivery and sometimes would pay less than the official price. On the other hand, in deficit areas in times of scarcity very little would be sold. Hesselmark and Lorenzl (1976, 176-177) conclude their study of maize marketing by lamenting that the board "seems not to be able to reach producer price stabilization in surplus areas. . . [and] does not reach its objective of consumer price stabilization in rural deficit areas."

Such problems have led some observers to condemn the NCPB for inefficiency and corruption. While the studies mentioned above and a recent study commissioned by

Table 1—Rural market maize grain prices, September 1984

Market	Province	Price	Ratio to Bondo Price	Difference	Transport Cost from Bondo ^a
		(KSh/kilogram)		(US\$/metric ton)	
Embu	Eastern	5.00	3.0	221	38
Kiambu	Central	4.22	2.5	169	27
Luanda	Western	2.13	1.3	29	4
Mumias	Western	1.94	1.1	17	6
Bondo	Nyanza	1.69	1.0	0	...

Sources: Based on data from Kenya, Ministry of Agriculture, Development Planning Division, "A Summary Report of the Food Situation as of 31 October 1984," Ministry of Agriculture, Nairobi, November 1984 (mimeographed); data for transport costs from Bondo derived from Michael Schluter, *Constraints on Kenya's Food and Beverage Exports*, Research Report 44 (Washington, D.C.: International Food Policy Research Institute, 1984), p. 63.

Note: An exchange rate of KSh 15.00 = US\$1.00 is used here.

^a Schluter's estimates of operating costs for a 7-ton truck in 1982 are increased by 40 percent to account for inflation (the CPI increased 31 percent during this period) and an additional 20 percent to allow for normal profit.

⁸ The \$ symbol refers to U.S. dollars throughout this report.

the World Bank have shown that the board is not the most efficient of organizations, it is important to understand that it has been assigned an impossible task (Booker International 1983). The board is supposed to buy whatever is offered at a price over which it has no control; to sell whatever is demanded at a second price over which it has no control; to export and import only when given approval by the cabinet, not when it seems profitable to do so; and to store whatever the result of all these other decisions requires. Even an exceptionally efficient organization could be forced to lose money when operating under such constraints. The board's bending of the law by allowing stock levels to influence its buying and selling operations is understandable.

Government policy, then, must be distinguished from government pronouncements. In Kenya, as elsewhere, "most farmers have learned by painful experience that simple statements of government intentions to stabilize prices—or even to require them by law—are ineffective" (Timmer, Falcon, and Pearson 1983). The government claims to provide complete price stability to its consumers and producers, but the evidence presented above clearly shows that this is not the case. Because the pronouncements about price stability are unworkable, given the fiscal constraints of the NCPB, and since the foreign-trade decisions are out of its hands, the board is forced to buy and sell in ways that produce considerable price variability for consumers in rural deficit areas and producers in rural surplus areas. Thus maize prices in many rural areas are determined more by parastatal officials trying to keep their corporation solvent than by senior decisionmakers weighing one goal against another.

The government's official policy is to set the price at which maize will be sold long before the size of the crop can be estimated, with real prices being almost constant from year to year. Yet simple accounting identities show that if prices are to remain constant in real terms while production is variable, either the stock level or the foreign-trade account or both must absorb the instability. Another option that may appear to work is to limit NCPB sales or purchases by quantitative restrictions. All of these methods have been used in recent years. In 1979/80, government stocks decreased almost to zero, maize was imported, and the NCPB did not sell all that was demanded from it at the official price.⁹ The situation in 1984/85 was similar, although government stocks had opened the market year at a much higher level and consequently were above 100,000 tons when the imports began to arrive. Conversely, in 1981/82 stocks were increased substantially, exports were approved (after a lag), and the NCPB did not buy all the maize that it was offered.

The quantitative restrictions, however, do not truly limit price instability because of the large percentage of maize that is bought and sold in private markets. While such restrictions allow the government to continue to buy or sell maize at the controlled price, they lead to large increases in local market prices (or decreases in years of abundant maize), thus causing price instability for rural consumers and producers.¹⁰ So the only tools that successfully control price stability for all market participants are trade and storage policies. Historically, then, the goal of real price stability has been met only through the facade of stable official prices, while fluctuations in local market prices have been large.

The logical recommendation under such conditions is to add some flexibility to the official policy. For many years, a number of analysts have recommended freeing the

⁹ "Where the Maize Really Went," *The Standard* (Nairobi), July 2, 1980.

¹⁰ Bates (1981) argues that food policies in Africa have tended to favor the urban market for political reasons. This is less true in Kenya than elsewhere (see Jabara 1986; Meilink 1985).

marketing system in one way or another, most often arguing for a buffer stock scheme that would allow prices to fluctuate within a band. The Maize Commission of Inquiry discussed the issue in 1966 (Kenya 1966, 22). More recently, Gsaenger and Schmidt (1977) and Schmidt (1979) have argued that the NCPB should not play a primary marketing role but should hold buffer stocks and a strategic reserve.

It was in this context that the government appointed an Inter-Ministerial Working Group to study proposals for reforming the maize marketing system in 1983. This working group, of which the author was a member, developed a simulation model of the price band/buffer stock schemes that were being proposed at the time (Kenya 1983a). The policies under consideration would have caused the marketing system to be more flexible by making three changes: (1) decision rules for foreign trade would be approved ahead of time by the cabinet, so that each specific trade would not be delayed by cabinet deliberations; (2) movement controls would be relaxed to allow the private sector to accomplish what the NCPB has been unable to do historically—integrate the maize market across regions; and (3) prices would be allowed to fluctuate within a band, so that producers and consumers would bear some of the consequences of unstable production.

The working group was concerned with rationalizing the present system (changes 1 and 2) and investigating the benefits of allowing prices to fluctuate (change 3). The simulation models conducted by the working group assume that the first two changes are made and then attempt to measure the trade-off between cost and price flexibility in a dynamic, stochastic framework. The report clearly shows that much lower fiscal costs are possible when prices are allowed to fluctuate.

The analysis in the present study will begin in the next chapter by discussing the appropriate methodological approach, starting with the simulation methods used by the working group. Readers whose primary interest is in the policy conclusions may wish to skim this chapter. The model is developed in Chapter 4, with results presented in Chapter 5.

METHODOLOGICAL APPROACH

The Analytical Context: Simulation and Optimization

The Inter-Ministerial Working Group appointed in 1983 to study marketing reform proposals used a simulation approach to measure the costs of different policy options. The two parameters that determine this type of price band/buffer stock scheme (these are defined explicitly in the following section) are varied and tested in a large number of possible 10-year production cycles. It is necessary to make annual production stochastic, since the underlying nature of the problem is instability in production. Including 10 years in each cycle allows the model the opportunity to test for performance of the policies in sequences of good and bad years. This dynamic component is necessary to test different strategies for stock carry-outs.

Each of the three objectives—price stability, fiscal cost, and imports—is measured over the 10-year cycles for every variation of the policy parameters, thus defining a set of feasible combinations of the objectives. Trade-offs between pairs of objectives are then calculated by holding the third objective constant. These trade-offs will be accurate reflections of the cost of increasing the level of each objective, provided the underlying model is sufficiently realistic and *the price band/buffer stock schemes are the most efficient policies for meeting the three government objectives.*

There are reasons for suspecting that such schemes are inefficient. In a closed economy with a somewhat different objective function, Newbery and Stiglitz (1981) have shown that price band policies are quite inefficient. Since the government tools in the price band scheme do not respond to changes in the world price, it would seem that these policies may be even less efficient in an open economy. This consideration alone suggests that there are alternative policies that are more efficient and might yield a different measure of trade-offs because they flexibly adjust to states of the world.

There are two alternatives for measuring trade-offs accurately: modify the price band policies to make them more flexible to state parameters such as the world price; or set up an optimizing model that chooses the best level of the government control variables for each possible state of the world, and then simulate the chosen policy.

Although optimizing is bound to be more difficult, there are four reasons for using an optimization method rather than simply simulating additional chosen policies. First, since there is a potentially infinite number of possible policies, the choice of which ones to simulate will be to some extent ad hoc. As Eaton (1980) points out, when simulating different types of administrative rules "we cannot know whether an untested solution exists which better achieves the stated goals. Optimization is the preferred mode of analysis for screening many alternatives."

Second, optimization ensures that the trade-offs between objectives are measured accurately. When optimizing a multidimensional objective function, trade-offs between objectives are measured by varying the weights on the different objectives (Blandford and Lee 1979). Different weights on the three government objectives will force the optimizing algorithm to choose different policies. If the weight on minimizing imports is increased, for example, optimization ensures that the policy is adjusted in such a way that the cheapest method of reducing imports has been chosen.

Parts of this chapter appeared in Pinckney 1986b, 451-466.

Third, finding the optimal policy allows for measurement of the degree of suboptimality of alternative policies. Once the optimal policy for a given set of weights is found, it can be simulated in the same way as a price band/buffer stock scheme, thus allowing a direct comparison between the two types of policies. This is especially important for policy recommendations, since administrative rules generally are easier to understand and implement than the policies that come out of optimization routines. Yet ease of communication and implementation is an objective of the government that is difficult, if not impossible, to build into the optimizing process. Once the optimal values of the objectives are known, the values of the objectives produced by the administrative rules can be compared, and a trade-off between complexity and cost can be computed.

Fourth, differences between the way the optimal policies and the administrative rules respond to the state of the world can be studied, and the administrative rules can be adjusted in ways suggested by the optimal policies. This should make possible both reductions in the complexity/cost trade-off and the formulation of an administrative rule that is much more efficient than one that would have been tested without considering the optimal policies.

Thus there are several potential benefits of using optimization techniques. The costs, however, in terms of program development and analysis are considerably larger for optimization routines than for simulation of administrative rules. This study will use optimization methods and consider in conclusion whether or not the benefits gained from their use outweigh the costs.

Defining the Price Band/Buffer Stock Policies

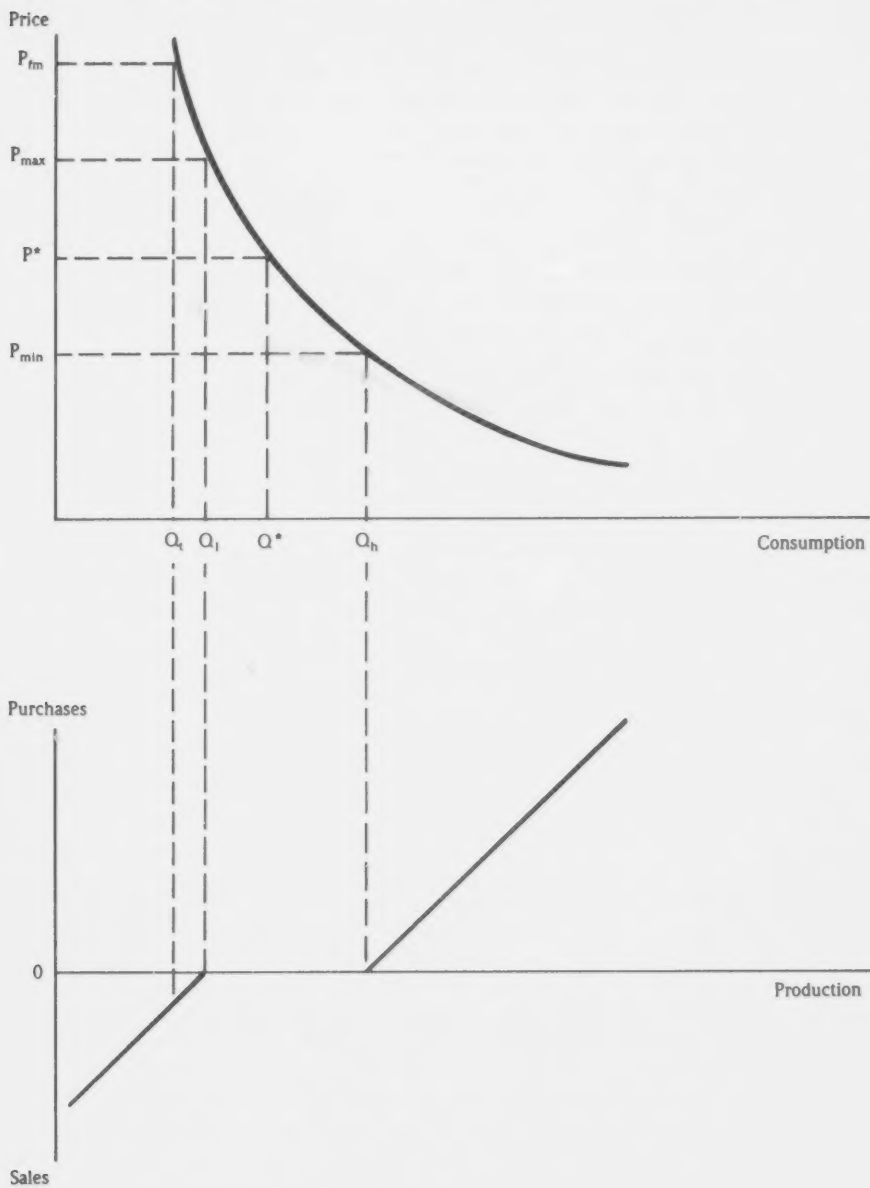
The basic price band/buffer stock policies studied by the Inter-Ministerial Working Group are described in this section. For brevity, these policies will be termed "price band policies" in what follows. It is assumed that the government has a target price, P^* . A maximum price is set, $P_{\max}$, at which the government promises to sell sufficient quantities of maize to meet demand. Similarly, a price, $P_{\min}$, is set, at which the government will buy all the maize which it is offered. Between $P_{\min}$ and $P_{\max}$, prices are allowed to fluctuate freely. Two graphs (Figure 1) can help explain the basic policy. In the top graph, $P_{\max}$, P^* , and $P_{\min}$ are drawn on the Y-axis. Each of these prices corresponds to a quantity consumed on the X-axis. Now suppose that actual production in year t is Q_t which corresponds to a free market price, P_{fm} , greater than $P_{\max}$. The government would have to sell $Q_t - Q_t$ in order to keep the price at or below $P_{\max}$.

The lower graph shows the relation between production and government purchases under such a system. The board buys all that is produced above Q_h , and makes up the total difference between Q_t and actual production. This graph will be particularly helpful later on when comparing price band policies with those that result from optimizations.

How should these three prices (P^* , $P_{\min}$, and $P_{\max}$) be chosen? The government does not want stocks to grow year after year or to be depleted continually. Price band/buffer stock schemes may be useful for stabilizing prices from year to year but are unlikely to be successful if the government is trying to raise or lower long-run market prices. So the working group takes P^* to be the free market price during a normal weather production year, and chooses the logarithms of $P_{\min}$ and $P_{\max}$ to be symmetrically distributed around the logarithm of P^* . This is approximately equal to holding the price within equal percentage bands.

The rules for exporting and importing are more difficult to choose. In the past, Kenya has allowed its own stock position to determine whether or not trade should

Figure 1—Net purchases function implied by price band policy



take place. Another alternative would be to allow imports and exports at other times if prices warrant it, or to adjust the stock triggers, depending on the prevailing world price. The working group simulations follow past government practice and allow stocks alone to trigger trade. The price band schemes therefore have minimum and maximum stock figures, $S_{\min}$ and $S_{\max}$, which serve as trigger points for foreign trade. Since imports will not arrive in Kenya until three or four months after orders are placed, the $S_{\min}$ should be greater than zero. For the purpose of dealing with production instability, however, the important parameter of the model is not $S_{\min}$ or $S_{\max}$ but $(S_{\max} - S_{\min})$, the difference between maximum and minimum stock levels. This difference will be termed "stock variability." The purpose of stocks in a dynamic, stochastic world is to absorb shocks in present production and move grain from a surplus time period to a deficit time period. The degree to which stocks are able to accomplish this task is determined by the stock variability, not by $S_{\min}$ or $S_{\max}$ in isolation from each other.

This is seen most clearly by considering an example. Policies with larger stock variabilities will have higher average stock levels, lower imports, and lower exports. But the difference between two policies with the same figure for stock variability is only a constant. Suppose that policy A imports at a stock level of 100,000 tons and exports at 400,000 tons, and policy B imports at a stock level of 200,000 tons and exports at 500,000 tons. Both policies, then, have a stock variability figure of 300,000 tons. But the only difference between these policies when simulated will be the net present value of storing 100,000 tons for the entire time period, assuming that policy B begins with 100,000 tons more in store than policy A. This figure is a constant. Imports and exports will be identical, and average stock levels will only differ by 100,000 tons. Thus the single parameter of stock variability is required to determine the policy rather than two separate stock triggers.

So, given that P^* is constant across policies and that the price bands are symmetric, the price band policies studied by the working group differ only in two parameters: the allowable price variability and the stock variability.

The simulation model of the price band schemes is similar to the country models developed by Reutlinger and Bigman and Abbott's proposed methodology (Reutlinger 1983; Reutlinger and Bigman 1981; Reutlinger, Eaton, and Bigman 1976; Bigman 1982a, 1982b, 1985; Bigman and Reutlinger 1979a, 1979b; Abbott 1985). There are significant differences, however, between their models and the ones used here and by the working group. The Bigman and Reutlinger models are used primarily to measure the efficacy of implementing one type of policy versus another type, such as relying on trade to stabilize supplies versus relying on buffer stocks. Also, while they attempt to build their models for a generic country, it is obvious that any results will be particularly dependent on the specific parameters and policy structure chosen. Many of the published results use parameters relevant to India, including modeling a ration shop system similar to the one in use in that country. Kenya's status as a marginal importer and exporter with large differences between import and export parity prices makes its situation considerably different from the countries modeled in their publications. Finally, the goal of measuring the trade-offs between government goals leads to a different type of analysis than one focusing on choosing one type of policy over another.

Choice of Optimization Technique

There are at least three optimization techniques that have been used to analyze storage problems in the literature. These are Bigman's method, Eaton's programming method (Eaton 1980), and stochastic control methods (Rausser and Hochman 1979;

Kim, Goreux, and Kendrick 1975; Kendrick 1981; Arzac and Wilkinson 1980) or dynamic programming.¹¹ They will be considered in order.

Bigman has developed a technique that finds the optimal price band/buffer stock policy (Bigman 1985; Bigman and Yitzhaki 1983). If the government has already decided that a policy of this type is to be implemented, this is a useful technique. Otherwise, there could be a more efficient policy that does not fit into this category. Thus, in the absence of government direction in the matter, this technique cannot yield the four benefits outlined above.

Eaton's method requires that the problem be formulated with a quadratic or linear objective function and linear constraints (Eaton 1980). Production must be characterized as a random variable that is not influenced by the endogenous government decision variables. Thirty or more sequences of, say, 10 years each of possible future production are then produced by a random number generator. A series of multiperiod quadratic programming problems are then formulated, one for each 10-year production sequence, with the level of production for each year entering as a constraint. The quadratic programming results give optimal levels of the control variables for each particular future production sequence. The control variables clearly will be different for each production sequence and are chosen by the model with full knowledge of future production. It is as if Eaton acknowledges that this is unrealistic, since the model is making use of facts that would be unknown at the time decisions are made. However, he suggests that more general optimal policies can be gleaned from these particular implementations by regressing the levels of the control variables on values of other control and state variables that are known at the time decisions would have been made.

The problem with this technique is that the best specification of the regression equations is unknown. Given the results of the quadratic programming problems, it is difficult to move ahead. Should only linear decision rules be considered? Will the relationship between, say, carry-out stocks (the amount of stock held at the end of a market year—in this report, total stocks minus the import cushion) and production be the same for high levels of production as for low? That is unlikely, but it is unclear what levels of production should be included in the regression. So Eaton's method is not a true optimization method, since there is no way to guarantee that the optimal specification for policy structure has been tested in the regression analysis. Thus, it cannot yield the four benefits listed above.

Stochastic control methods leave no question about optimality if prior conditions are satisfied. Solving the continuous optimization problem by calculus techniques, however, is notoriously difficult. Kim, Goreux, and Kendrick (1975) are unenthusiastic about recommending this technique to other researchers dealing with storage problems, as they conclude their article by admitting that they cannot be certain their computations are correct. So if control methods are to be useful, they will have to be simplified in some way.

There are at least two ways of simplifying the problem: using certainty equivalence methods or using dynamic programming. Theil (1957) has shown that a stochastic control problem with a quadratic objective function and linear state transition equations

¹¹ Bellman 1957 is the classic presentation. Howard 1960 concentrates on the Markov chain methodology, which is employed for world prices in this study. In the area of optimal stockholding, Gustafson (1958) was the pioneer. Gardner (1979) and Burt, Koo, and Dudley (1980) use dynamic programming in more complex models. Gardner 1979 and Plato and Gordon 1983 are particularly useful for the practitioner. Johnson (1981) and Johnson and Sumner (1976) attempt to apply dynamic programming to stockholding problems of LDCs. The manual for the Microsolve program (Jensen 1983) is especially helpful for composing a computer program to solve such a problem; it is also an excellent teaching tool.

has a certainty equivalence solution; that is, the variability of the stochastic variable makes no difference in the choice of the optimal policy. If the problem can be stated in those terms, the solution can be found simply by filling in the values of some variables in an equation.

The Kenya model that will be used here has a quadratic objective function and could have been constructed with a linear demand curve, allowing for this solution technique. But consider the following implications of certainty equivalence: Suppose there are two countries, each with an average production of 10 million tons. In one, the standard deviation of production is 5 million tons, while in the other the standard deviation is only half a million tons. If certainty equivalence is correct, provided both countries have the same opening stock and the same production, and face the same world price, then they should carry out the same stock despite the large difference in the standard deviations. This is counterintuitive.

It is also incorrect. The problem is that the derivation of the certainty equivalence theorem assumes that there are no inequality constraints. But stocks, imports, and exports are all strictly non-negative variables (because of the difference between import and export parity, imports and exports must be costed differently and thus must remain distinct rather than being added together as trade). Such non-negativity conditions make the certainty equivalence formulation unworkable.

In spite of these problems, Arzac and Wilkinson (1980) have developed a storage model for grains that uses certainty equivalence methods and compared their results to those from the pioneering dynamic programming work of Gustafson (1958). They comment that "the numerical [dynamic programming] solution and the linear rules [from the certainty equivalence formulation] give very similar results for stocks greater than or equal to 35." This statement is correct (except that 35 should refer to total supply rather than stocks). But Gustafson goes on to compute his model for different levels of production variability, and he gets considerably different results with a higher level of variability. The certainty equivalence formulation gives the same result for every level of variability, since it ignores the standard deviation of production. Table 2 shows the level of total supply (production plus opening stocks), Gustafson's results with a low variability of yield, his results with a high variability of yield, and the Arzac and Wilkinson certainty equivalence results.

Most striking are the negative stock levels with a total supply of 25 and 30 in the certainty equivalence results. The authors claim that the "negative stocks produced by

Table 2—Optimal storage versus certainty equivalence storage

Total Supply	Optimal Storage		Certainty Equivalence Storage
	Low Variability	High Variability	
25	0.0	0.0	-4.5
30	0.0	0.0	-1.1
35	2.4	2.9	2.3
40	5.9	6.4	5.6
45	9.7	10.2	9.0

Sources: Based on data from Enrique R. Arzac and Maurice Wilkinson, "Dynamic Analysis and Optimal Control of Agricultural Commodity Markets," in *Applied Stochastic Control in Econometrics and Management Science*, ed. Alain Bensoussan, Paul Kleindorfer, and Charles Tapiero (Amsterdam: North Holland Publishing Company, 1980), pp. 41-77; and Robert L. Gustafson, *Carryover Levels for Grains: A Method for Determining Amounts That Are Optional Under Specified Conditions*, Technical Bulletin 1178, U.S. Department of Agriculture, October 1958.

the linear rules can be interpreted as a reduction in the working stocks of the economy (which are implicit in this analysis)" (Arzac and Wilkinson 1980, 46). But this is surely not a proper interpretation, since there is no mechanism for the buildup of working stocks in the model.

They also suggest that the certainty equivalence solution with stocks truncated at zero "seem[s] to produce a very good approximation to the numerical solution" (Arzac and Wilkinson 1980). While not far off for Gustafson's original case, it is considerably off for Gustafson's case with a larger variance, and Gardner (1979) cites an example in which the certainty equivalence stock level is only about 50 percent of the dynamic programming stock level. Clearly, it is fortuitous that the particular case Arzac and Wilkinson cite turns out to be close. It is thus wrong for an analyst to assume a priori that the certainty equivalence solution will be close to the dynamic programming solution. In fact, Gardner (1979, 17) makes the point that the

use of optimal control methods which substitute the expected value of future production for the probability distribution of production can lead to recommended carryover stock levels substantially lower than the optimal carryover. Indeed, in almost every practical application, optimal storage increases significantly as the variance of future production increases.

It is clear, then, that certainty equivalence methods are not appropriate for the analysis at hand.¹²

The second possible simplification of the stochastic control problem is dynamic programming. This involves making the problems discrete rather than continuous and solving by means of a backward recursion. The algorithm is best understood by a simple example.¹³ Suppose there is a country where production is either 8 or 12 units every year, with the two outcomes being equally likely. Storage capacity is 3 units and everything that is not stored is consumed. The cost function to be minimized is

$$\Sigma (C_t - 10)^2 + 0.1 \cdot S_t$$

for all years t in the time horizon, where C_t represents consumption in year t and S_t represents closing stocks. Say there are T years in the time horizon. Dynamic programming generally uses a backward recursion technique to solve the problem. Beginning with the terminal year T , all possible opening states of the world are enumerated, each one being evaluated for all of the possible stock carry-outs. This is shown in Table 3.

Consider the first row of the table: if production is 8 and there are no carry-in stocks, then carrying out no stocks implies consumption of 8 and thus a cost of

$$(10 - 8)^2 + 0.1 \cdot 1 = 4.0.$$

Storing 1 unit implies consumption of 7, leading to a cost of

$$(10 - 7)^2 + 0.1 \cdot 1 = 9.1.$$

¹² Control methods are most useful and interesting when the systematic variations from period to period are significant, making the nonstochastic case nontrivial. Then certainty equivalence methods can be used to approximate a solution, and the stochastic case can be solved by minimizing deviations from the certainty equivalence case. This is the technique used by Kim, Goreux, and Kendrick (1975).

¹³ Gardner (1979, 5-14) gives a more detailed example of a similar problem.

Table 3—Dynamic programming example: terminal year payoffs

Production	Opening Stocks	Cost If Closing Stock Is				Minimum Cost
		0	1	2	3	
8	0	4.0	9.1	16.2	25.3	4.0
8	1	1.0	4.1	9.2	16.3	1.0
8	2	0.0	1.1	4.2	9.3	0.0
8	3	1.0	0.1	1.2	4.3	0.1
12	0	4.0	1.1	0.2	1.3	0.2
12	1	9.0	4.1	1.2	0.3	0.3
12	2	16.0	9.1	4.2	1.3	1.3
12	3	25.0	16.1	9.2	4.3	4.3

The rest of the table is computed in a similar fashion, with the cost of the best stock option shown in the right-hand column.

That completes the analysis for the terminal year T. Now, consider the situation in year T-1. Since the objective function is the same, the cost in year T-1 alone of storing a particular quantity, given opening stocks and production, will be identical to the values computed for year T. However, the total cost in year T-1 is the sum of the cost in year T-1 plus the expected future cost in year T. These total costs are computed in Table 4 for the state in which production is 8 and carry-in stocks equal 2 in year T-1.

Consider the first row of the table. Table 3 shows that the cost in year T-1 of carrying out zero stocks when production equals 8 and opening stocks are 2 is zero. But if no stocks are carried out in year T-1, then there are two possibilities for year T shown in Table 4: either production will be 8, with a cost of 4.0, or production will be 12, with a cost of 0.2. Since those outcomes are equally likely, the expected cost in year T of carrying out zero stocks in year T-1 is 2.1. The best choice, then, is to consume 9 units and store 1, with a total expected cost of 1.75. Note that when only one year is considered, it is optimal to consume all of production and stores when production is 8 and stores are 2, but when the subsequent year is considered, it is best to consume less in the present year and store 1 unit.

To complete the dynamic programming recursion, similar tables would have to be computed for the other seven possible states of the world in year T-1. Each table would yield the cost of being in that state of the world in year T-1. Then the recursion would move back to year T-2 and proceed in a similar fashion until year 1 is reached.

It is clear from this example that dynamic programming can solve dynamic, stochastic problems similar to Kenya's maize-marketing problem. Dynamic programming has the additional advantage of allowing inequality constraints on the variables. The constraints

Table 4—Dynamic programming example: year T-1 payoff calculations

Carry-out	Cost in Year T-1	Cost in Year T If		Expected Cost in Year T	Total (T-1 + T)
		Production = 8	Production = 12		
0	0.0	4.0	0.2	2.10	2.10
1	1.1	1.0	0.3	0.65	1.75
2	4.2	0.0	1.3	0.65	4.85
3	9.3	0.1	4.3	2.20	11.50

Note: Production = 8; carry-in stocks = 2.

do not have to be linear, so unlike Eaton's method or certainty equivalence techniques, a nonlinear demand curve can be used. In fact, a limitation of this approach is that as a discrete system, inequality constraints are required on every variable. Thus it is difficult at times to ensure that the results are not constrained by inequalities that are a function of the particular specification of the solution algorithm rather than of the theoretical model.

Before accepting dynamic programming as the proper technique for this study, it is necessary to consider the two charges that other analysts have brought against it. These are the need for a simplistic objective function, and the "curse of dimensionality."

Although the example considered above is very simple, the criterion for optimality in most applications of dynamic programming to storage problems has not been much more complex than the one used there. As Bigman and Yitzhaki (1983, 2) point out, these functions have generally been "a single valued social welfare function (generally, the sum of the present and the expected future consumers' and producers' surplus)." Indeed, Eaton (1980, 20) points out that maximizing producer/consumer surplus after subtracting costs of storage "has been the sole objective of dynamic programming analyses of grain reserves." Cochrane's (1980) critique of such an objective function is only the best known of many others.

The use of simplistic objective functions, however, has been the result of researchers' choice, not a requirement of the solution technique. The solution algorithm used in the present study is simply a brute-force search; this is slow computationally, but it is effective in dealing with the three objectives, with nonlinear costings, and with a nonlinear objective function. Importantly, all the programs can run on microcomputers, so the costs are not excessive.¹⁴ Consequently, there is no need to avoid dynamic programming because of the need for a complex objective function.

The second problem with dynamic programming is the curse of dimensionality (Bellman 1957). This problem multiplies in difficulty with the number of possible states of the world in the model. As an example of the effects of the curse, consider the model to be developed below. The state of the world will be determined by three variables: world price, production, and opening stocks. Nine discrete levels of production and 30 discrete stock levels are allowed. If these were the only two state variables, there would be $9 \times 30 = 270$ possible states of the world. By adding one more variable, world price, with 7 discrete levels, there are now $7 \times 9 \times 30 = 1,890$ possible states of the world. The problem has increased more than sevenfold in terms of computing time. The curse consequently constrains the size of the model that can be developed. To some extent, this constraint can be relaxed by using larger computers or more efficient solution techniques.¹⁵

The curse is not a major problem for this study. As discussed in the next chapter, data problems and the desire to keep the model understandable would have led to a fairly simple model even if a different solution technique had been used.

Thus dynamic programming is clearly the best choice of optimization technique for the problem at hand. Each of the four benefits of optimization mentioned above—

¹⁴ Programs are listed in Pinckney (1986a). Recent versions of both programs are available from the author in Microsoft Fortran 4.0.

¹⁵ Burt, Koo, and Dudley (1980) use a solution technique that is not a backward recursion. Their method allows other variables from a more complex econometric model to influence the expected value of future costs. The disadvantage is that expected values are no longer exact, as they are when a backward recursion algorithm is used. Nevertheless, this technique is interesting and warrants further research in countries where data limitations do not rule it out.

making selections across many types of policies, measuring trade-offs accurately, maximizing the value of the objective function for comparison with suboptimal policies, and providing suggestions for modifications of administrative rules—is gained through the use of dynamic programming.

In order to take advantage of the last three benefits, however, it is necessary to take the analysis one step beyond the optimization algorithm itself. As mentioned above, the optimal policies must be simulated in the same framework as the price band schemes in order to compare measurements of trade-offs, to judge the suboptimality of the price band schemes, and to learn from the optimal policies in order to adjust the price band schemes. Before the optimal policies can be simulated, however, they need to be made “continuous” rather than discrete. This is accomplished by linearly interpolating the discrete optimal policies across state variables. While it is unlikely that the resulting policy will be the optimal continuous policy, it will not be substantially different if the discrete optimization includes a large enough number of levels of each state variable. This is discussed more fully in the following chapter.

A PRODUCTION INSTABILITY MODEL FOR KENYA

Food Production and Consumption Data in Kenya

In a review of the problems associated with formal analyses of food security issues in East Africa, Lele and Candler (1981, 105) warn against "planning without facts," and go on to say

We do not believe that the exercises of economists in the international agencies are inherently futile; but we do warn that such analyses should not start with the facile assumptions that all the required data are readily available and that the system is totally commercial.

The quality of data on both food crop production and consumption in Kenya is poor. The only hard data available are on purchases and sales of grains by the NCPB, but these series are inappropriate for use as proxies for total production. The presence of the parallel, informal market as a competitor to the board causes the NCPB to take a larger proportion of the crop during good production years than in poor production years, since the ratio of the local market price to the official price varies. Consequently, NCPB purchases and sales fluctuate much more dramatically than production.

Yet if the NCPB numbers are inaccurate indicators of production, which production series should be used? The Kenyan government publishes several conflicting series, and others are available from international organizations. Table 5 presents the series used by the Development Planning Division of the Ministry of Agriculture (DPD/MOA) along with the series from the Food and Agriculture Organization of the United Nations (FAO) and the U.S. Department of Agriculture (USDA). For comparison, the NCPB sales and purchases data are listed also.

There are large differences between the series, most obviously in 1976/77 when the FAO series shows an increase of over 60 percent, the USDA shows an increase of over 15 percent, and the DPD/MOA series increases less than 1 percent. The figures show smaller differences between these series in recent years.

The DPD/MOA series is built up from district and provincial estimates of maize production made by Ministry of Agriculture officers in the districts. Goldman (1983) uses the provincial estimates to test for links between NCPB sales and purchases series and the production series. He estimates the following equations:

$$\text{BUY} = 205 + 0.53 \text{ RIFT} - 0.85 \text{ OPENSTOCK}$$

Years: 72-82;
Adjusted $R^2 = 0.93$,

$$\text{SALES} = 0.15 \text{ INVENT} - 0.75 \text{ WEST} - 1.45 \text{ EAST}$$

Years: 71-73, 75-81;
Adjusted $R^2 = 0.61$,

where

BUY	= NCPB purchases,
SALES	= NCPB sales,
RIFT, EAST	= production in those provinces,
WEST	= production in Western and Nyanza provinces,
OPENSTOCK	= NCPB opening stocks, and
INVENT	= opening stocks plus current year's purchases.

All t-statistics are significant at the 2.5 percent level.

These equations give strong support to the DPD/MOA production series, since they relate the building blocks of that series to the only hard data available. Unfortunately, it is impossible to compare the competing series by comparable tests, as those data are not reported by province. Nevertheless, because the DPD/MOA series is supported it will be used in the analysis at hand.

On the consumption side there is no series that exhibits any links with hard data. The DPD/MOA production series is at least a direct estimate of the desired quantities, albeit by people of varying levels of skill and interest. The best consumption series, on the other hand, is a derived series that leaves out a critical variable: changes in private stocks. Table 6 shows the derivation of an apparent consumption series for the last 15 years.

The series is nonsensical when considered as "consumption." It can more appropriately be called "disappearance." The problems are most obvious for 1975/76, 1981/82, and 1984/85; the first two were good crop years after relatively poor ones had

Table 5—Different series of maize production in Kenya

Year	DPD/ MOA	USDA	FAO	NCPB Purchases	NCPB Sales
(1,000 metric tons)					
1970/71	1,181	1,500	1,400	240	278
1971/72	1,473	1,300	1,500	379	191
1972/73	1,384	1,700	1,660	455	358
1973/74	1,297	1,600	1,600	335	490
1974/75	1,387	1,600	1,400	448	343
1975/76	1,688	1,900	1,600	552	604
1976/77	1,748	2,195	2,600	536	397
1977/78	2,080	2,205	2,553	244	146
1978/79	1,740	1,895	2,169	235	513
1979/80	1,604	1,450	1,800	131	491
1980/81	1,768	1,750	1,620	393	685
1981/82	2,502	2,200	1,980	696	532
1982/83	2,348	2,340	2,349	621	473
1983/84	2,030	2,000	2,178	504	768
1984/85	1,423	1,275	1,275	366	803

Sources: Based on data from Food and Agriculture Organization of the United Nations, *FAO Production Yearbook*, various issues (Rome: FAO, various years); U.S. Department of Agriculture, Economic Research Service, *World Indices of Agriculture and Food Production*, Statistical Bulletins 669 and 710 (Washington, D.C.: USDA, July 1981 and July 1984); U.S. Department of Agriculture, Foreign Agriculture Service, *Foreign Agriculture Circular*, *Grains: World Grain Situation and Outlook* (FG-2-85) (Washington, D.C.: USDA, 1985); and unpublished data from the Development Planning Division, Ministry of Agriculture, Nairobi.

Notes: Figures are for crop years, July to June. DPD/MOA = Development Planning Division/Ministry of Agriculture; USDA = U.S. Department of Agriculture; FAO = Food and Agriculture Organization of the United Nations; and NCPB = National Cereals and Produce Board.

Table 6—Derivation of maize "consumption" series

Year	Production	NCPB Net Sales	"Consumption"
		(1,000 metric tons)	
1970/71	1,181	38	1,219
1971/72	1,473	-188	1,285
1972/73	1,384	-97	1,287
1973/74	1,297	155	1,452
1974/75	1,387	-105	1,282
1975/76	1,688	52	1,740
1976/77	1,748	-139	1,609
1977/78	2,080	-98	1,982
1978/79	1,740	278	2,018
1979/80	1,604	360	1,964
1980/81	1,768	292	2,060
1981/82	2,502	-164	2,338
1982/83	2,348	-148	2,200
1983/84	2,030	264	2,294
1984/85	1,423	437	1,860

Source: Unpublished data from the National Cereals and Produce Board, Kenya.

depleted private stocks. Consumption shows a big jump, which is at least partially an increase in private stocks. For 1984/85, it is clear that private stocks were drawn down to make up for the production shortfall.

There is virtually no evidence about the magnitude of private stocks in the country. The Integrated Rural Surveys of the 1970s report figures for private stocks held by smallholders, but even these numbers are derived from numbers for production and consumption, since the survey questionnaire did not ask about stocks. As an example of the magnitudes involved (which should only be considered indicative), Integrated Rural Survey 3 estimates that in July 1977, private stocks held by small farmers were 132,000 tons; this figure increased to 203,000 tons by July 1978, implying that the consumption figure in Table 6 for 1977/78 should be decreased by 71,000 tons.¹⁶ Since 1977/78 was the second good year in a row, this figure is unlikely to be abnormally high. In addition, since large farmers and traders are not included, it is clear that changes in private stocks might be quite large relative to the variation in the consumption series.

Given the problems caused by a lack of information on the demand side, it will be necessary to forgo any direct estimate of price elasticity of demand if this study is to avoid being lumped with the "mechanistic analyses of meaningless numbers" that Lele and Candler (1981, 107) criticize. In such a situation it is more reasonable to make judgments about the magnitude of some important parameters than to use data series that are known to be far from correct. The absence of hard data also affects the type of model that can be employed, as is made clear in the following section.

The Model

The purpose of a model is not to mirror the real world. The rationale for modeling is that the real world is too difficult to understand in its entirety, and the analyst can

¹⁶ Figures are from Booker International 1983, Annex 8, Appendix 1, Tables 8 and 9. In July of 1977 and 1978, government stocks were 400,000 and 490,000 tons, respectively, or more than double the IRS estimate of smallholder stocks. The IRS estimates, however, are suspect.

gain a better understanding of the forces at work by selecting certain aspects of the world to study in depth. There are two opposing motives for the analyst: first, the desire to include all the interactions that will affect significantly the goals of the model; second, the need to keep the model simple and understandable. A model that leaves out key relationships can cause the analyst to give incorrect advice; a model that tries to include too much can leave the analyst foundering "in a limbo of unending data requirements, impossible 'debugging' problems, and general ineffectiveness" (Clark, Jones, and Holling 1979, 7). The result of these problems can be a black box model that no one, including its builder, can understand or interpret (see Johnston and Clark 1982, 231-234).

Clearly, balancing the two goals is an art and not a science. The point of balance will depend heavily on the goals of the analysis at hand. But as Holling (1978, 57) laments, "all too often, it is the technique that grabs the lead, and the problem is then bent and redefined to suit." Since one of the goals of this analysis is to have an effect on decisionmakers, it is even more important than usual to have a model that is clear and straightforward (Labys 1975, 372). This study, then, avoids the Charybdis of a black-box model by navigating rather close to the Scylla of a simplistic model.

Therefore, a simple model underlies both the simulation and the optimization procedures. For each equation the degree of simplicity is defended below. In some cases, a slightly different model is used in the simulation analysis than in the dynamic programming. These differences will be described also. Discussion proceeds by examining first the unified market assumption. This is followed, in order, by a discussion of supply, demand, the trade and stock equations, the world price equation, and the objective function. Then other types of objective functions are considered, followed by a description of the price band/buffer stock decision rules. Finally, the parameters of the model are selected in the final section of the chapter.

Unified Market

The maize market in Kenya is treated as one unified market in the simulation and optimization exercises. Since this assumption is made for simulations of future policy rather than estimation of parameters from past experience, the assumption does not imply that the Kenyan maize market has been fully integrated in the past. Table 1, which presents maize prices in different parts of Kenya in September 1984, clearly shows that markets have not been fully integrated. To a large extent, this lack of integration has resulted from an official government policy of totally stabilizing prices that the government cannot implement, given fiscal constraints. For example, in September 1984 the NCPB was not selling all that was being demanded at the official price. There has thus been a government-induced lack of integration.

This study is examining the cost savings to the government that result from providing the NCPB with sufficient fiscal resources to defend successfully floor and ceiling prices after building some official price flexibility into the system. Therefore the changes in policy being modeled here would lead to a higher degree of integration of the maize market, with prices in different markets differing by less than the width of the price band. It is thus appropriate to make the single market assumption for the purpose of designing a national supply stabilization strategy.

Nevertheless, prices will vary across the country and across seasons within the limits allowed by the policy. Consequently, an analysis that includes regions and seasons is important when deciding on the tactics of implementation of the supply stabilization strategy. This analysis, however, can be introduced into a 12- to 18-month model after the major decisions on strategy are made. Attempting to include regions and seasons

in the multiyear model that is necessary for designing stabilization strategy would lead to unnecessary complications, obscuring the important lessons on policy design.

Supply

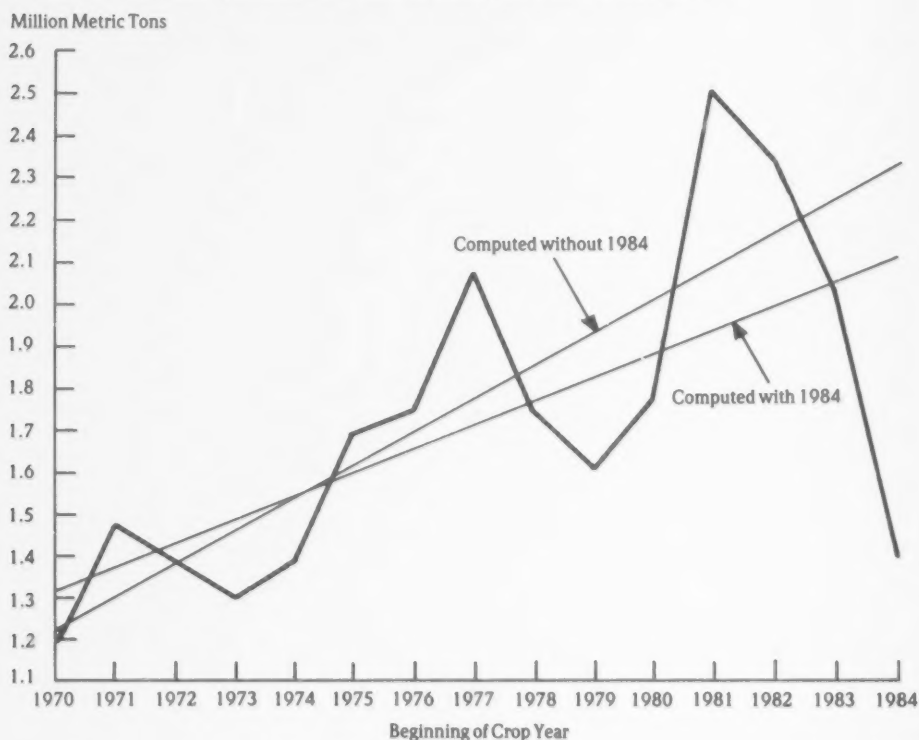
Production is modeled here as a stationary, normally distributed, uncorrelated time series:

$$Q_t = Q_0 + u_t, \quad (1)$$

where Q_t is production in year t , Q_0 is the mean, and u_t is the random element in year t . The random term u_t is normally distributed with an expected value of zero. Critics of this specification might focus on the following areas: maize production in Kenya has increased at a rapid rate over the last several years, so a series without a trend is inappropriate; an autocorrelation term should be included; the model ignores supply response to price; and although production can be modeled as a random variable, it is not normally distributed. These objections will be discussed in order.

Absence of a supply trend. It is undoubtedly the case that maize production in Kenya has grown rapidly in the last 15 years. Figure 2 shows the DPD/MOA production series for maize from 1970/71 to 1983/84. The less steeply rising line is the linear trend computed by regressing production on time for the entire period. This corresponds

Figure 2—Maize production and trends, 1970/71-1983/84



to a trend of about 3.3 percent at the mean production level for the period. The more steeply rising line is the trend computed from a regression that leaves out the 1984/85 drought year; it corresponds to growth of about 4.5 percent per year. Thus, although there is considerable area for disagreement about the magnitude of the trend, there can be no doubt that it is large and positive. A large component of this increase, however, has been area expansion, which is unlikely to increase as fast in the future. At the same time, there is considerable potential within the country to raise maize yields through better husbandry practices and development of improved varieties. So increases in production on the order of 3.5 percent per year over the next 10 years are not unreasonable to expect.

The expected growth in demand, however, is quite close to expected growth in production. Demand growth is affected primarily by three factors: population growth, growth in per capita income, and urbanization. Present population growth is 3.8-4.0 percent per year. Urban population is expected to grow at a rate of 7.8 percent per year. If per capita income remains approximately constant, maize demand will grow at about 3.5 percent per year, since the per capita consumption of maize in urban areas is only about 75.0 percent of the rural per capita consumption. Thus, given the rate of maize production increase and assumed rates of growth in demand, the real price of maize in a normal weather year should remain fairly constant. Since there is much uncertainty about the trend in maize production, and since the estimates of maize consumption are even worse, it is best to make a straightforward assumption about ignoring trends and consider any policy recommendations that come out of the analysis about stocks, for example, as relating to the percentage of a normal crop rather than an absolute number. This has the advantage of allowing the dynamic programming model to have the same structure every year, and thus come to a stable solution after several iterations. Although the absence of trends will make estimates of cost too low, it should not affect the measure of trade-offs between the goals, which is the primary purpose of the analysis.

Autocorrelation. Autocorrelation may enter production series in four ways: if farmers have naive expectations that next year's price will equal this year's price (the cobweb effect); if farmers have a target level of on-farm stocks; if other government policies are constant for a period of years, then change to a different mix for a few years, then change again; and if rainfall is autocorrelated. In this analysis it is assumed that the government's goals are well known to and believed by the populace. The government's desired price does not change from year to year, since the absence of trends implies that the equilibrium price in a normal weather year is constant. Given these assumptions, in the simple price band models the expected price is the same every year, regardless of the previous year's price. It is more difficult to characterize the rather complex policies that result from dynamic programming, although it can be said with certainty that the expected price will vary inversely with government stocks. The regression analysis of some of the optimal policies carried out in Chapter 6 indicates that a policy with a fairly large standard deviation of price (\$12.10) produces an expected price 7.2 percent below normal when stocks are at their maximum and world price is at its minimum. The expected price is 6.4 percent above normal in the opposite situation. It should be understood that these are the extremes, and most years would be considerably closer to the mean. So if farmers are rational and the government is straightforward, the autocorrelation resulting from expectations will be negligible.

The second possible source would result if the farmers' target level of on-farm storage influences their production decisions. In this case, a bad year that depletes on-farm stocks would induce increased plantings in the subsequent year; similarly, a

good year that increases stocks would lead to decreased area planted to maize in the next year. This, then, is an argument for negative autocorrelation, for which there is no empirical evidence. The autocorrelation parameter measured over the years 1970 to 1983 is $+0.12$.¹⁷ Although there may be some supply response to on-farm stock levels after exceptionally bad years, this positive (although insignificant) autocorrelation parameter indicates that the effect does not occur often enough to have a large average effect.

The third source of autocorrelation, fairly consistent government policies that change periodically, is assumed away in this analysis. Any attempt to measure trade-offs between government objectives must choose which possible instruments the government will use to affect the area under analysis and hold all other government policies constant. Agricultural credit policies, for example, have been left out and are assumed to be constant throughout the time horizon. Similar assumptions must be made when doing any analysis of this type.

The final possible source of autocorrelation, rainfall, is the subject of some debate in Kenya. Many persons in the country believe in rainfall cycles, with the most often heard number being 10 years. Although Kenya has reasonably good rainfall data, going back 30 or 40 years in some cases, these series are too short to check for cycles of this length. Although there is some evidence in the rainfall data for shorter periods of autocorrelation in single agroecological zones, Kenya's ecological diversity lessens the effect of any autocorrelation that might be present in individual zones.

Supply Response. Supply response to price occurs only when expectations about relative prices in one year differ from expectations about relative prices in another year. As explained above, expected prices will be constant for the price band policies and close to constant for the optimal policies. Long-term expected prices are the same in both cases. Therefore, the appropriate supply elasticity would be a short-term elasticity, which would be smaller than a long-term elasticity. The recent study by Booker International surveys other studies of supply response of maize production in Kenya, in which estimates range from 0.15 to 0.95. Their own estimating equations in conjunction with comparisons from other studies leads them to a best guess of around 0.40.¹⁸ Even this number seems somewhat large for a staple food in a poor country. Timmer, Falcon, and Pearson (1983) point out that from comparative experience one would expect the supply elasticity for a basic cereal grain to be between 0.20 and 0.30. Nevertheless, if the short-term supply elasticity is taken to be the higher value of 0.40, even assuming a large deviation of expected price from normal of 7 percent, the maximum expected change in maize production is less than 3 percent. In most years it will be much smaller.

There are at least two possible nonprice factors that could induce a supply response. The first, unequal changes in expected yields for competing crops, is assumed to be unimportant. This is equivalent to assuming that trends in yields for competing crops are approximately equal to trends in maize yields. The second factor, a target for on-farm maize stocks, has been discussed above under autocorrelation.

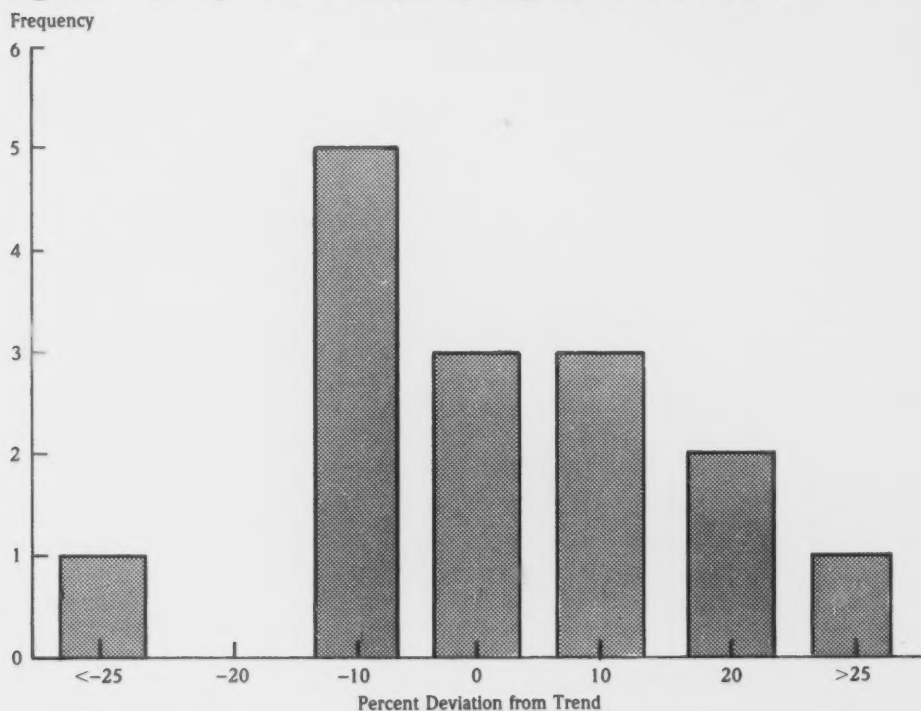
¹⁷ As measured from 1970 to 1984 the parameter is $+0.39$. This is considered inaccurate because the probability of a shortfall in production of the degree that occurred in 1984 is less likely than 1 in 15 (the implicit assumption of the regression analysis). See the discussion on the standard deviation of production below.

¹⁸ Booker estimates supply response for different regions of the country. A weighted average of their different numbers is about 0.4. See Booker International 1983, Annex 5, Appendix 2, Table 1, and Annex 5, Appendix 4, Table 1.

Thus, nonprice supply response factors are unimportant, while supply response to changes in expected price could be as large as 3 percent in rare years for the optimal policies. Ignoring this price response will not lead to a large bias, since it is dwarfed by the standard deviation of production, which will be 10 percent (discussed below). The direction of the small bias will be toward overestimation of costs and stock requirements, since the expected price in the optimal policies will be higher in years of high world price and low stocks. Thus positive supply response will occur in exactly those situations when the country has the most to lose from a production shortfall.¹⁹ Sensitivity analysis of the standard deviation of production will capture the effects of supply response to some extent.

Normality. Some analysts believe that production should not be considered to be normally distributed, arguing that since both exceptionally heavy rainfall and exceptionally poor rainfall lead to poor crops, production will be skewed downward. Indeed, U.S. aggregate production data for feedgrains tend to be skewed in this direction (Gustafson 1958). Data from Kenya, however, tend to show the opposite. Figure 3 shows a frequency diagram of percentage deviations from trend using data from 1970/71 to 1984/85. While the series is too short to warrant any conclusions, the apparent

Figure 3—Maize production frequency diagram, 1970/71-1984/85



¹⁹ However, rational expectations that include knowledge of other farmers' supply response will dampen this effect. See Gardner 1977 and Plato and Gordon 1983 for a discussion of solution techniques for the difficult problem of including supply response in a dynamic programming model.

skewness is to the right.²⁰ Leaving out 1984/85, the series is dramatically skewed upward. Some a priori reasoning supports upward skewness. A significant percentage of maize area in Kenya is planted in semiarid areas. In these areas, the standard deviation of production is often larger than the mean. Thus, production in these areas is never more than one standard deviation below the mean, while it may occasionally be two or three standard deviations above the mean. In about 10-20 percent of all years, production is almost nil. In effect, the bottom tail of the distribution is chopped off, leading to a distribution that is skewed upward. Positive skewness that decreases with application of nitrogen was also found by Day (1965) for maize in the Mississippi Delta. Thus there are a priori arguments for skewness in both directions, conflicting evidence from the United States to support skewness in either direction, and some evidence from Kenya to support skewness upward. Amid these mixed signals it is both prudent and convenient to depend on the Central Limit Theorem and assume a normal distribution.

Demand

As stated in the data section, demand is even more of a problem than production and therefore is modeled even more simply, as a nonstochastic, constant elasticity curve that depends only on the price of maize:

$$\ln(D_t) = C + e_m \cdot \ln(P_t), \quad (2)$$

where

$\ln(\cdot)$ = natural logarithm function,

D_t = demand for maize in year t ,

C = constant,

e_m = own-price demand elasticity for maize (a negative number), and

P_t = price of maize in year t .

Such a specification is in line with Bigman's (1985) suggestion. As pointed out above, there is no trend in demand. In addition, demand is not stochastic. While it would be easy to make demand stochastic in the simulation models, the dynamic programming models would become more difficult to compute because of the aforementioned curse of dimensionality.

Stochastic demand is not, however, important relative to stochastic supply. The main source of stochastic demand would be fluctuations in real per capita income. The coefficient of variation of real GDP per capita from 1972 to 1985 (during which time GDP per capita shows no trend) is 3.3 percent. The average income elasticity for maize in Kenya used in the Booker study is +0.60.²¹ Thus the appropriate coefficient of variation of demand would be 2.0 percent, which is negligible compared with the importance of supply variations.

²⁰ Measuring skewness in this way assumes that the trend line represents normal weather years. Clearly, this may not be the case.

²¹ Calculated from Booker International 1983, Annex 5, p. 33, and Annex 5, Appendix 3, Table 3.

Maize, however, is an important income-producing crop for a large segment of the population, and fluctuations in maize production are included in the model. Thus it would be possible to include demand fluctuations that result from changes in income associated with maize production fluctuations. This factor, however, turns out to be negligible. The gross value of maize production accounts for approximately 5.0 percent of Kenya's GDP. With a coefficient of variation of production of 10.0 percent and income elasticity of 0.6, the coefficient of variation of demand resulting from this source is only 0.3 percent. It is consequently not worth including.²²

After the nonstochastic nature of demand, the second point to note is that the demand curve is constant elasticity. A constant elasticity curve is more appropriate than a linear curve and less ad hoc than a kinked curve. A linear demand curve implies that as price increases, demand responds more flexibly to price. This is an unlikely occurrence for the most important source of calories in a poor country.

A third assumption is the absence of other prices in the model. As mentioned above, this analysis assumes that all other government policies are held constant, so to the extent that government controls prices, the terms should all be absorbed in the constant. There is, however, a problem in that weather affects production of all crops, not maize alone. FAO (1984) estimates that from 1979 to 1981, maize accounted for 40 percent of total calorie consumption. The next seven most important sources of calories are sugar (10 percent), wheat (6 percent), oils and fats (6 percent), cassava (6 percent), sorghum and millet (5 percent), pulses (5 percent), and potatoes and sweet potatoes (3 percent). Total calorie consumption from all seven of these alternative sources, however, is no greater than the calories consumed from maize alone. Prices of sugar, wheat, and oils and fats are effectively controlled by the government.

Although the remaining crops are grown to a large extent in different agroecological zones with different weather patterns, there are nevertheless significant correlations in the production of some of the different calorie sources. A shortfall of rain that leads to a poor maize crop will raise prices of maize and thus decrease consumption; however, if the low rainfall also diminishes the bean crop, the rise in the price of beans will increase demand for maize, thus dampening the own-price effect. Since bean calorie consumption is only about 12 percent of maize calorie consumption on average, the effect from beans alone will not be large. But in a year like 1984/85, when the maize, bean, and potato crops all failed, the cross-price effects may have been significant, leading to a smaller decrease in maize demand than would have been forecast by looking at maize prices alone. It is difficult to know the magnitude of these effects, however, due to the absence of any data on potatoes and beans and on how much maize was distributed as food aid.

Although this is a problem for a simple model of demand, there seems little alternative to the formulation above. Adding additional crops would increase the costs of the study significantly (primarily by complicating the dynamic programming analysis) while clouding the interpretation of results. If reasonably good time series data were available for other crops, these costs might be offset by the benefits of increased realism. But when the absence of data would require heroic assumptions about even the most basic facts, the costs of including the additional crops are higher than any potential benefits. Clearly, the situation would be quite different in a country with a more complete data base.

²² This factor could be important in a regional model for major maize-producing regions.

Trade and Stock Equation

The clearing equation used is as follows:

$$D_t = Q_t + M_t - X_t - (S_t - S_{t-1}), \quad (3)$$

where

D_t = demand for maize in year t ,

Q_t = production in year t ,

M_t = imports in year t ,

X_t = exports in year t , and

S_t = government stocks in year t .

Since the government controls imports, exports, and stocks, this can be simplified by defining a variable NP to be government net purchases (NP_t):

$$NP_t = -M_t + X_t + (S_t - S_{t-1}). \quad (4)$$

Substituting equation (4) into equation (3) yields

$$D_t = Q_t - NP_t. \quad (5)$$

There is some debate in Kenya about the importance of private stocks, which are not included here. While there is no question that such stocks are large during certain seasons of the year, some observers believe that the levels change little from one year to the next because real official prices are fairly constant. The only evidence available, mentioned above, shows stocks of small holdings changing by 73,000 tons in one year.

There are two distinct reasons for holding private stocks in Kenya: security and speculation. It is likely that small farm households have a desired level of carry-out stocks for family security that is not particularly price sensitive. After poor harvests these stores are depleted, and then are replenished after the next good crop. Casual observation in different parts of rural Kenya confirms this belief, and the maize disappearance (consumption) figures in Table 6 are consistent with it.

The amount of grain stored from year to year for speculative purposes in Kenya probably has been small. This is to be distinguished from seasonal speculation on local markets and short-term speculation on changes in official government prices. Annual price speculation has rarely been profitable in the urban areas, where the NCPB has been relatively successful in holding real prices constant. In rural areas, it is more difficult to arbitrage large quantities across years, particularly since the practice is illegal. While illegality is obviously not a complete deterrent, the cost of the activity is high because of the need for bribes and secrecy.

Unfortunately, other than the two data points from Integrated Rural Survey 3, there are no time series data whatsoever on private stocks in Kenya, and nothing but hearsay and anecdotal evidence to go on. For this type of analysis, the private stock buildup and run-downs will correspond to some extent with similar activity in government stocks. Thus, leaving out this type of security, private stocks may overestimate the level of government stocks necessary to gain a certain level of price stability. As for speculation, some of the policies modeled below would lead to significantly greater

changes in price from year to year than Kenya has experienced officially in the past. But if the private market's storage charges and discount rate are greater than or equal to the figures used here for the government—approximately \$25 per ton and 7 percent—full storage costs would never be covered for any of the policies modeled. So it is unlikely that the increase in speculation would be large.²³

For the simulation, it is necessary to relate price to the exogenous variable, production, and the government decision variables. This can be done by substituting equation (5) for D_t in equation (2):

$$\ln(Q_t - NP_t) = C + e_m \cdot \ln(P_t), \quad (6)$$

and solving for the logarithm of price:

$$\ln(P_t) = [\ln(Q_t - NP_t) - C]/e_m. \quad (7)$$

World Price Equation

The world price is modeled as a percentage random walk in the simulation models. This is equivalent to a random walk in logarithms. It is desirable for the optimization model to model world price so that the expected value of world price next year equals this year's world price. Some studies, such as the one by Knapp (1982), assume that world price behaves as a random variable with known mean and variance. If this is done, the expected value in the following year at times will be much higher or lower than the present price. The optimizing algorithm will then "borrow foreign exchange, increase imports, and put the additional grain in storage" (Knapp 1982, 201-202). This builds world price speculation into the model. But, surely, increasing imports of maize is an inappropriate way for a normally self-sufficient country like Kenya to speculate. If the government of Kenya knows that the world price behaves as a random variable with a particular mean and variance and knows that the present price is low, it should enter the futures market, not import more maize. In addition, if enough actors have this knowledge about world price, a large number of them will enter the futures market, and world price will no longer behave as a random variable with known mean and variance. So this assumption is inconsistent with the existence of futures markets. Modeling world price as a random walk, on the other hand, makes the expected value of the world price equal to the present price, so that there is never an incentive to speculate.

Three variants of the Dickey-Fuller test were run to see if the series of the logarithms of real maize prices from 1957 to 1986 behaves as a random walk with a unit root.²⁴ In the three model specifications below, the coefficient "B" is tested by the different parameters for difference from 1:

²³ Peck (1977/78) has shown that private storage in the United States increases with increasing changes in expected price, even though the difference is less than full carrying costs. If such a relation exists in Kenya, it will lessen the need for the government to hold stocks.

²⁴ The time series used is for U.S. gulf port no. 2 yellow maize prices, deflated by the U.S. wholesale price index. The tests are described in Dickey and Fuller (1979), using significance tables found in Fuller (1976). Simple t-statistics for the lagged variable are not appropriate tests. The article shows that the Dickey-Fuller test is more powerful than the Q-statistic (Portmanteau test) described in Harvey (1981, 48).

$$\begin{aligned} WP_t &= BWP_{t-1} + e_t, \\ WP_t &= A + BWP_{t-1} + e_t, \text{ and} \\ WP_t &= A + BWP_{t-1} + Ct + e_t, \end{aligned}$$

where

$$\begin{aligned} WP_t &= \text{world price in year } t, \\ A, B, \text{ and } C &= \text{estimated parameters,} \\ t &= \text{time, and} \\ e_t &= \text{error term.} \end{aligned}$$

All six tests are insignificant at the 10 percent level.

The third specification is of interest because time is included in the model. The estimated equation is as follows:

$$\begin{aligned} WP_t &= 0.378 + 0.76WP_{t-1} - 0.0049t; & (8) \\ & (0.16) \quad (0.0033) \\ R^2 &= 0.59, \end{aligned}$$

where the numbers in parentheses are standard errors. The negative trend is significant at the 10 percent level. The estimated trend is for world prices to decline by 0.5 percent per year. Nevertheless, a negative trend is not included in this model for three reasons. First, it is desirable for the optimization model to have the same structure in each of the model years so that a stable policy will be found. Including a negative trend would make this impossible. This added complication would not be a factor if the trend was certain to continue in the future and if it would imply quite different policies. This, however, is not the case. In mid-1987 it is not at all clear that world maize prices will continue their downward trend; in addition, the size of the historical trend is such that the effect of including it in the model would be small.

Thus, for the simulation, world price behaves as follows:

$$WP_t = WP_{t-1} \cdot (1 + u), \quad (9)$$

that is, the world price in year t equals the world price in the previous year times 1 plus a random variable u , which is distributed normally with 0 mean and a standard deviation of WSD. The number WSD is an estimate of the average percent change in world price from one year to the next.

In the discrete world of the dynamic programming models, it is impossible to allow the world price to behave as a random walk without including an unacceptably large number of possible world prices. With a smaller number of levels, either the expected price will not always equal the present price or, at the extreme price levels, there will be no possibility of a change in prices. To take a simple example, suppose that the model allows only three possible price levels: \$90, \$120, and \$150 per ton. If the price is \$120 in one year, it is easy to make the expected price in the next year also equal to \$120 by assigning equal probabilities to \$90 and \$150. But if the price is presently \$150, there is no higher price to which it can climb, so either the probability of the price dropping to \$120 or \$90 must be zero, or the expected price in the next year must be less than \$150.

The dynamic programming models use seven levels of world price and choose the latter option. Table 7 lists the expected price at each level of world price. The differences are rather small except at the extremes, where they are about US\$7 per ton. The discrete levels of world price also make a percentage random walk difficult to implement, so the optimizing model approximates a normal random walk.

Government Objective Function

As presented in Chapter 2, the three government objectives included in the dynamic programming models are stabilizing prices around a normal-weather-year price, minimizing imports, and minimizing government expenditures. This objective function affects only the solution algorithm of the optimizing model. For the simulation models, the value of the objective function does not affect the decision variables, since the simulation models do not maximize or minimize an objective function. The average value of each of the three components of the objective function, however, is still computed for comparison with the optimal values.

In equation form, the goals can be stated as follows:

$$\text{Minimize: } GC = \sum [COST_t + a(P_t - P^*)^2 + bM_t]/(1 + r)^{t-1}, \quad (10)$$

that is, minimize GC, which equals the sum over all years of the government's fiscal cost, plus a parameter "a" times the square of the deviation of the present year's price from the target price $(P_t - P^*)^2$, plus a parameter "b" times imports (M_t), the quantity being discounted for time preference at discount rates. The parameters are weights that measure the importance of each of the objectives relative to the other two. These weights, which were referred to in Chapter 3, are varied in order to find policies that efficiently produce more of one objective and less of the other two. This allows for the measurement of trade-offs.²⁵ By not putting a weight on COST, the monetary unit becomes the numeraire of the system.

The nature of the objective function will be addressed by discussing, first, the price component and discounting; second, the components of government cost; and finally, other possible objective functions.

Table 7—Expected values of world price in dynamic programming models

Price in Year t (US\$/metric ton)	Probability of Price in Year t + 1							Expected Price (US\$/metric ton)
	\$60	\$80	\$100	\$120	\$140	\$160	\$180	
60	0.725	0.239	0.035	0.001	...	...	...	66.24
80	0.239	0.486	0.239	0.035	0.001	...	...	81.46
100	0.035	0.239	0.451	0.239	0.035	0.001	...	100.06
120	0.001	0.035	0.239	0.450	0.239	0.035	0.001	120.00
140	...	0.001	0.035	0.239	0.451	0.239	0.035	139.94
160	...	...	0.001	0.035	0.239	0.486	0.239	158.54
180	...	...	...	0.001	0.035	0.239	0.725	173.76

²⁵ In a linear programming environment, an equivalent formulation would be to include two of the three objectives as constraints, and vary the right-hand side in order to trace out trade-offs between objectives (see Eaton 1980). In dynamic programming, this is not a feasible alternative, and the different objectives must be included and weighted in the objective function.

Deviations of price from the goal enter as a squared term (Blandford and Lee 1979). In a country like Kenya, where prices have been controlled for so long, penalizing the absolute value of the deviation would not be correct; a 50 percent increase in price is much more than five times worse than a 10 percent increase. The penalty should be symmetric, since farmers make up such a large percentage of the population. The simplest functional form that satisfies these two criteria is the one that is used.

All three terms are discounted in future years. Clearly, a government would trade a 10 percent increase in price this year for a 10 percent increase in price five years in the future were such a deal possible, at least in part because the official making the decision might leave the government before then.

The COST term has three annual components and a fourth cyclic component. These are within-country operations, foreign trade costs, storage costs, and stock replacement costs. They will be described in turn.

Within-Country Operations. Net proceeds of within-country sales are $P_t \cdot NP_t$, where NP_t is government net purchases (so that NP_t is negative when the government sells maize).

Foreign Trade Costs. Foreign trade costs and benefits are difficult to compute in Kenya. Import parity prices usually are computed by adding local and foreign shipping costs to the world price, while export parity prices subtract local costs. The situation in Kenya is somewhat more complex for two reasons: first, in any one year, relatively small quantities of maize can be exported at a white maize premium, and second, food aid is available. An optimal maize policy should take advantage of both of these facts, so they must be built into the model.

Export premiums are available because white maize is usually a preferred commodity on the world market. The market is thin, however, and most countries that want to import white maize are short of foreign exchange. In 1983 and 1984, Kenya was able to make arrangements for the World Food Programme (WFP) to buy about 100,000 tons of Kenyan maize and ship it to third countries, mainly Somalia. The WFP saved money on transport and passed all those savings, plus a white maize premium, on to Kenya. The total premium for Kenya was about \$50 per ton. Such deals are somewhat difficult to negotiate and probably could not be arranged for large quantities of maize. To some extent, these arrangements are more like WFP aid for Kenya rather than business deals; therefore, if Kenya were to export 300,000-400,000 tons of maize in one year, it might be reasonable to expect the WFP to buy the first 100,000 tons at a high price even if considerable amounts of additional maize were being exported with no premium. So in the model, Kenya exports its first 80,000 tons in any one year at a price that is \$40 above the prevailing world price, with the premium decreasing linearly and disappearing for exports other than the first 120,000 tons. Thus the gains from exports are as follows:

$$\text{If } X_t \leq 80,000, \text{ then} \quad (11)$$

$$XP_t = X_t \cdot (WP_t + 40 - XCOST).$$

$$\text{If } 80,000 < X_t < 120,000 \text{ then}$$

$$XP_t = X_t \cdot (WP_t - XCOST) + [3200 + (160 - X_t)/2 \cdot (X_t - 80)].$$

$$\text{If } X_t \geq 120,000 \text{ then}$$

$$XP_t = X_t \cdot (WP_t - XCOST) + 4000,$$

where

- XP_t = export proceeds in year t ,
 X_t = exports in year t ,
 WP_t = world price in year t , and
 $XCOST$ = cost of exporting.

On the import side, food aid complicates the picture in two ways. First, it is clear from 1979/80 and 1984/85 that Kenya can arrange for food aid in crisis years. While the amounts received in those years may have been larger than they would have been in a tighter world maize market, there is no doubt that the United States and other donor countries will support Kenya to a significant extent in times of trouble. But food aid will not be available in years of minor shortfalls, and in serious drought years the first batch of imports would have to be ordered commercially in order to receive the maize quickly. A second problem is that a considerable proportion of food aid is not available for the government to sell. Since this study deals only with marketed and own-produced maize, not with relief, aid that is freely distributed should not be included in the models. (To the extent that free food aid substitutes for food that would be purchased in the market, it should be included in total supply.) Finally, although it is difficult to predict the response of donors to a shortfall in production, they are likely to base aid decisions on estimates of total supply (production plus government stocks, since private stock figures are unavailable) rather than production alone or planned government imports. There is no obvious model to use here, but past actions indicate that donors will make up about 40 percent of the difference between total supply and a figure that is 100,000 tons below normal-year production. For instance, if normal-year production is 2.0 million tons, government stocks are 50,000 tons, and production is 1.8 million tons, donors would be expected to provide 20,000 tons in food aid to the marketing board. Since Kenya has to pay transport costs on food aid, the accounting is as follows:

$$\text{If } Q_t + S_{t-1} > Q_0 - 100,000, \text{ then} \quad (12)$$

$$AID_t = 0.$$

Otherwise,

$$AID_t = 0.4 \cdot [Q_0 - 100,000 - (Q_t + S_{t-1})], \text{ and}$$

$$MC_t = M_t \cdot (WP_t + MCOST) - AID_t \cdot WP_t,$$

where

- Q_t = production in year t ,
 S_t = opening sales in year t ,
 Q_0 = normal-year production,
 AID_t = food aid in tons in year t .
 MC_t = total cost of all imports in year t ,
 M_t = commercial imports and aid in year t ,
 WP_t = world price of maize in year t ,
 $MCOST$ = cost of importing, and

DT = domestic component of import costs
minus the cost of handling domesti-
cally purchased maize.

These models of food aid and export premiums are admittedly ad hoc. Given a situation in which both food aid and export premiums have significant effects on Kenya's maize strategy, however, it would be clearly wrong to leave them out of the model.²⁶ The only solution is to make the kind of reasoned judgments used here and include these components in the model.

Storage Costs. Storage charges include losses, railage to and from the stores, and any costs associated with turning over the stocks to keep them fresh. These costs are considered to be constant per unit of stock. As the maximum stock level chosen by the optimizing program is less than the presently available storage in Kenya, there is no need for increasing marginal costs of storage to reflect increasing costs of the space.

$$SC_t = S_t \cdot STCOST, \quad (13)$$

where

SC_t = total storage cost in year t ,
 S_t = closing stocks in year t , and
 $STCOST$ = cost per ton of holding stocks.

Note that the storage facilities themselves are neither costed nor amortized. This is for two reasons: storage is already in place, has virtually no rental value, and is not considered a cost in the country; and donor funds probably would be made available for construction of storage if more were desired.

Interest charges are not included in the costs of storage. This causes some problem in explaining the model to policymakers, who see large interest costs in the financial report of the NCPB each year. But as Gardner (1979, 18) points out, it would be incorrect to include such costs. This is best seen by considering a risk-neutral private trader, who will store grain until his expected costs equal his expected benefits. That is, until

$$P_{t+1} = (P_t + STCOST)(1 + r), \quad (14)$$

which is equivalent to

$$P_{t+1}/(1 + r) = P_t + STCOST,$$

where $STCOST$ is storage cost and r is the interest rate. If the interest rate equals the time value of money, the discounted objective function used in the model will consider two policies to be of equal cost in exactly these circumstances. An objective function that charged interest on stocks and also discounted future benefits would include a second $(1 + r)$ term in the denominator on the left-hand side, incorrectly adding another cost to the storage operation.

If the market interest rate differs from the perceived time value of money—which it may, since there could be constraints on Kenya's ability to borrow foreign exchange—then those policies that increase borrowing should add the differential interest charges

²⁶ A similar model for wheat in Pakistan has been run with no export premiums. The optimal net purchases function has the same shape and the same sensitivity to parameters. The only significant difference is the shape of the closing stock curve; in the Pakistan case no exports take place until the maximum stock level is reached.

to the other costs, and those policies that decrease borrowing should subtract the same. In this model, that would mean adding an interest charge to imports and subtracting interest charges from exports. This has not been done here, although such adjustments could easily be added to the model. Note that even if these charges were included, there would not be a direct interest charge on maize in storage, but policies that resulted in more exports (and thus lower levels of storage) would cost less.

Stock Replacement Costs. Charges for replacement of stock are included in the simulation models to facilitate the comparison of policies that end with different amounts in store. All models begin with 100,000 tons in year 0. The models end each cycle with anywhere from zero to 250,000 tons in store on average, with individual cycles varying more widely. Unless some allowance is made for these changes in stock level, the policies that end with low levels will appear to be more profitable, since they include the proceeds of selling the stock. There are two alternatives: (1) value the excess or deficit stock at a constant price and add the charge to the total for that policy, or (2) force the models to export or import in the final year in order to end up with exactly 100,000 tons. The latter option penalizes the optimal policies more than the price band policies, since the optimal policies on average hold more stock in years of low world prices. Since the price band policies will be compared with the optimal policies in chapters 3 and 4, option 1 is used here. The value chosen is the base year world price (which is equal to the average world price across all simulations because of the nature of the stochastic process).

$$RS = (S_0 - S_{10}) \cdot WP_0, \quad (15)$$

where

- RS = replacement stock charges,
- S_0 = closing stocks in base year,
- S_{10} = closing stocks in year 10, and
- WP_0 = world price in base year.

Note that the optimizing algorithm does not consider this charge in its choice of the optimal policy. Since the desired optimal policy is one that ignores the terminal conditions in the model, including these charges would not affect the stabilized policy.

Other Types of Objective Functions

Most optimizing studies of stabilization policy have not used a multiple-attribute, weighted utility function as the objective function but have used consumer/producer surplus, considering it a proxy for national welfare. As Gustafson (1958, 48-49) has shown, the result of using consumer/producer surplus is the free market solution, provided the private discount rate and storage costs equal those of the government. A model with this objective function is used as a reference. It is inappropriate for the bulk of the analysis, however, for the following reasons.

First, one supposed advantage of using consumer/producer surplus is that benefits and losses of various policies can be ascribed to different groups in the economy. Indeed, a substantial amount of the price stabilization literature deals with this issue. But as Sarris and Taylor (1978, 149-159) have shown, the shape of the demand curve is of central importance in determining such gains and losses. Given the paucity of information about demand in Kenya, it would be at best pointless and at worst misleading to measure triangles around a curve of unknown shape.

A second objection is pointed out by Cochrane (1980). For a staple food in a poor country, income effects of price changes will be large but totally ignored by the welfare measure. In addition, consumer surplus from resulting price changes in other commodities could be large but unmeasured.

Finally, regardless of whether or not such an objective function is appropriate in other contexts, it is inappropriate here because the purpose of this study is to affect government policy by measuring trade-offs between government objectives. The Kenyan government *wants* to stabilize prices; in fact, ever since independence (and before) the government has claimed to control prices directly. In such a situation, it is important to try to discover how much this sort of total price stability costs the government *in terms of its own objectives*, and how much of its other objectives it can "buy" by "selling" some price stability. For this study to be effective, the objective function of the analysis must be one relevant to the government that allows for the measurement of trade-offs, and not "an illusion created by an alternate purchasing power procedure which is non-operational" (Cochrane 1980, 508). A multiple-attribute, weighted utility function is the appropriate tool for measuring trade-offs, since the weights on the parameters can be varied directly to come up with points in the noninferior set (Blandford and Lee 1979).

A different approach would be to transform the government objective function used here into a utility function that would include a risk-aversion coefficient, as Buccola and Sukume (1987) have done for Zimbabwe.²⁷ Alternatively, the utility function of a government official can be measured directly, as Parton (1979) has done for wool in Australia. The latter is an interesting approach and might be particularly useful for deciding on the form of the function. But given the complex nature of the decisionmaking process for changing public policy, it is unclear whose utility function should be measured (Cohon and Marks 1975, 213). In addition, given the political sensitivity of the issue, it seems likely that the responses to counterfactual questions could be quite different from the decisionmaker's actual response in a crisis.

In sum, the objective function used here, like the rest of the model, is a simple tool formulated to address the specific substantive issue at hand, which allows for the measurement of trade-offs between three important government objectives with adjustments in a minimum number of parameters.

Price Band Decision Rules

This completes the description of the model for the dynamic programming runs. Government response to any particular production outcome is not specified ahead of time, but results from the maximization of the objective function. The policy rules, therefore, are endogenous. For the price band simulations, it is necessary to specify government policy toward different levels of production, stocks, and world prices. So a simple set of administrative rules is added to the previously defined market structure, as outlined in Chapter 2. The government chooses a price P^* as its target, which is the normal production year equilibrium price with no government intervention:

$$\ln(P^*) = [\ln(Q_0) - C]/e_m, \quad (16)$$

where Q_0 is normal-weather-year production, C is the constant in the demand equation, and e_m is maize demand elasticity. The government then chooses a range in which to

²⁷ It is debatable, however, whether or not governments should be considered risk averse. See Valdés and Siamwalla 1988, especially p. 118.

allow prices to vary without government intervention. The maximum percent price variation, W , is both added and subtracted from $\ln(P^*)$ to produce the maximum and minimum allowed price:

$$\ln(P_{\max}) = [\ln(Q_0) - C]/e_m + W, \text{ and} \quad (17)$$

$$\ln(P_{\min}) = [\ln(Q_0) - C]/e_m - W. \quad (18)$$

Substituting equation (7) into equation (17) for $\ln(P_{\max})$,

$$[\ln(Q_{\min} - NP_t) - C]/e_m = [\ln(Q_0) - C]/e_m + W, \quad (19)$$

where $Q_{\min}$ is the production level that corresponds to the maximum price, $P_{\max}$, and NP_t is net government purchases. Since all government decision variables are zero within these limits by definition, NP_t can be set to zero. Making that substitution and solving for $Q_{\min}$ yields

$$Q_{\min} = \text{EXP}[\ln(Q_0) + e_m \cdot W], \quad (20)$$

where EXP is the exponential function. Since e_m is a negative number, $Q_{\min}$ is less than Q_0 if W is greater than zero.

A similar derivation yields the figure $Q_{\max}$:

$$Q_{\max} = \text{EXP}[\ln(Q_0) - e_m \cdot W]. \quad (21)$$

So if production is between $Q_{\max}$ and $Q_{\min}$, the government does not intervene; if production is outside those limits, the government buys or sells maize:

$$\text{If } Q_t > Q_{\max}, \text{ then} \quad (22)$$

$$NP_t = Q_t - Q_{\max}.$$

$$\text{If } Q_t < Q_{\min}, \text{ then}$$

$$NP_t = Q_t - Q_{\min}.$$

$$\text{If } Q_{\min} \leq Q_t \leq Q_{\max}, \text{ then}$$

$$NP_t = 0.$$

Exports and imports are determined by the opening stock level, net purchases, and the level of stock variability, $S_{\max}$. For computational purposes, the minimum stock level will be considered to be zero, but as pointed out in the previous chapter, in the actual case a minimum stock level equal to two or three months maximum net sales should trigger imports, since there is a delay between ordering and receiving foreign maize (a positive minimum stock level would have to be specified in a model that includes seasons).

$$\text{If } S_{t-1} + NP_t > S_{\max}, \text{ then} \quad (23)$$

$$X_t = S_{t-1} + NP_t - S_{\max}, \text{ and}$$

$$S_t = S_{\max}.$$

Otherwise,

$$X_t = 0, \text{ and}$$

$$S_t = S_{t-1} + NP_t,$$

where

S_{t-1} = opening stocks in year t ,

NP_t = government net purchases in year t ,

X_t = exports in year t , and

S_t = government stocks in year t .

$$\text{If } S_{t-1} + NP_t < 0, \text{ then} \quad (24)$$

$$M_t = -(S_{t-1} + NP_t), \text{ and}$$

$$S_t = 0.$$

Otherwise,

$$M_t = 0, \text{ and}$$

$$S_t = S_{t-1} + NP_t,$$

where M_t is imports in year t .

At this point, the model has been developed and the price band administrative rules defined explicitly. Appendix 2 includes outlines of the computer programs used for the simulation and optimization processes. In the next section, the price band simulations are compared and contrasted with the optimizing process.

Comparison of Price Band Simulation with Optimizing Algorithm

In order to take full advantage of the four reasons for conducting an optimization outlined in Chapter 3, it is necessary that the computation of the three components of the objective function for the optimal policies and the price band schemes be directly comparable. After running the price band simulation and the dynamic programming optimization, the results are not comparable because of several differences between the two models. These differences are enumerated in Table 8.

As indicated in Chapter 3, the differences between the models are reconciled by taking the dynamic programming solution and simulating it in the same way that the administrative rules are simulated. This requires that the following adjustments be made for the differences noted in Table 8 (numbers 1-7 below correspond to the numbers in the table).

1. As shown in the example in Chapter 3, the result of running a dynamic programming algorithm is a set of tables listing each possible state of the world and the optimal values of the control variables for each state in each year. Thus, for each possible combination of domestic production, world price, and opening stocks, the appropriate net domestic purchases and net foreign trade are listed. These optimal policies may vary in each year of the optimization run. Fortunately, models such as this one in which the system parameters do not vary from year to year will usually stabilize after

Table 8—Differences between price band simulation and dynamic programming models

Price Band Simulation	Dynamic Programming
1. Policy is identical in each year.	Terminal conditions affect policy in last several years.
2. State and control variables are "continuous."	State and control variables are discrete.
3. World price is modeled as a percent random walk.	World price approximates a normal random walk.
4. Ten-year cycles are run.	Program runs for an eight-year cycle, or until the policy stabilizes.
5. Replacement-of-stock charges are included.	Replacement-of-stock charges are not included.
6. Policy is determined by an administrative rule.	Policy is determined by minimization of present and expected future value of a cost function.
7. Feasible combinations of objectives are found by changing allowed price deviation and stock variability.	Feasible combinations of objectives are found by varying weights in the cost function.

several years, and these stabilized values ignore the terminal conditions. The model used here usually stabilizes after five or six years. The stabilized values are used in the simulation, so the optimal policy is constant across years.

2. The discrete values of the dynamic programming solution are linearly interpolated in order to approximate a continuous optimal policy.

3. The simulations of the optimal policy treat the world price as a percent random walk just as in the price band simulations. This leads to some slight suboptimality of the simulated policies, since the conditions under which optimization took place are different from the conditions of the simulation.

4. Ten-year cycles are used in the simulation of the optimal policies just as in the simulation of the price band schemes. Since the chosen optimal policy is a stabilized policy, and since the object is to test the stabilized policy rather than to reach certain terminal conditions, this is the appropriate method to use. There is no loss of optimality.

5. The addition of replacement of stock charges does not affect optimality for the same reason as given in number 4. The purpose is to test a stabilized policy; the replacement of stock adjustment is used to allow for comparison between policies that consistently end with different stock levels. If such charges had been included in the optimization process itself, the final few years of the optimization would change, but the stabilized policy would be no different.

There is no need to reconcile the last two differences between the models. Indeed, numbers 6 and 7 lead to the first two benefits of optimization: screening all possible policy alternatives and accurately measuring trade-offs between government objectives. These last two are the essential differences between using an optimizing algorithm to select the policy and choosing an ad hoc rule. It is because of the differences that the optimizing process can help the analyst learn how to adjust the administrative rules to be more efficient.

The next and final section in this chapter selects the parameter values that are used in the model.

Parameters for the Model

The key parameters in the model are as follows:

- Cost of importing: \$40 per ton, of which \$35 is foreign exchange.
- Cost of exporting: \$70 per ton, all local costs.
- Shadow price premium on foreign exchange: 15 percent.
- Maximum stock level: 580,000 tons.
- Discount rate: 7 percent.
- Opening world price: \$120 per ton.
- Standard deviation of the world price: 14 percent.
- Standard deviation of production in Kenya: 10 percent.
- Own-price demand elasticity of maize: -0.3.
- Normal production year equilibrium price: \$140 per ton.
- Cost of storage: \$25 per ton.

Costs of Importing and Exporting

The official estimate of the costs to the NCPB of preparing maize for export was \$80 per ton as of 1985.²⁸ Schluter (1984) gives a detailed breakdown of these costs as of 1981/82. Table 9 lists the costs as of that date, projects them to the 1985 total, and then makes two reasonable adjustments. First, the type of change in marketing policy envisaged by this study would decrease the purchase and transport charges incurred by the NCPB. It is assumed rather conservatively that this decrease would be 20 percent. Second, one large component of the export cost is the charge for bags. There are three ways these costs could be lessened: constructing bulk handling facilities both up-country and at the port, making use of some second-hand bags rather than all new bags, and using sisal bags rather than the present sisal/jute combination. Assuming that some combination of these measures is taken, the bag component of cost is decreased, first by the 10 percent duty on jute that Schluter includes, and then cut in half, for an overall decrease of 55 percent of the original estimate. The end result is a cost of exporting maize of about \$70 per ton.

Table 9—Costs of exporting maize

Component	Schluter's Costs 1981/82	DPD/MOA 1985 Total	Assumed Savings	Final Estimate
	(US\$/metric ton)		(percent)	(US\$/metric ton)
Primary marketing	17.0	19.3	20	15.5
Bags	10.1	11.4	55	5.1
Drying	10.5	11.9	0	11.9
Railage	28.6	32.4	0	32.4
Wharf charges	1.7	1.9	0	1.9
Insurance	1.2	1.4	0	1.4
Interest	1.4	1.6	0	1.6
Total	70.6	80.0		69.8

Source: Based on data from Michael Schluter, *Constraints on Kenya's Food and Beverage Exports*, Research Report 44 (Washington, D.C.: International Food Policy Research Institute, 1984).

Notes: DPD/MOA is Development Planning Division/Ministry of Agriculture. Parts may not add to totals because of rounding.

²⁸ Richard Goldman, personal communication, June 1985.

The costs for importing are similar to the costs for exporting. Throughout this study, the difference between the domestic selling and buying price of the NCPB is assumed to cover the board's costs. Imported maize is sold at the domestic selling price, which is the producer price plus the margin. The correct import parity price is thus the foreign transport cost—estimated at \$35 per ton²⁰—plus the difference between the domestic marketing margin and the costs of handling imported maize. The difference is about \$5 per ton, and would not be affected by the adjustments made in Table 9, since those adjustments would affect both local and imported maize.

Shadow Price of Foreign Exchange

It is widely perceived that the Kenya shilling is officially aligned close to its shadow rate, with the demand for foreign exchange somewhat higher than supply at official rates. A figure of 15 percent overvaluation is a reasonably good estimate. It is consistent with black market rates (Cowitt 1985).

Maximum Stock Level

In the price band models, the maximum stock level is part of the policy and never reaches levels where Kenya's present storage capacity would be exceeded. In the optimizing models, however, a maximum stock level has to be chosen, since all the variables are discrete. In the early stages of formulating the model some tests were done, and a stock level of 580,000 tons was selected, since the model did not choose to store more than 560,000 tons under any of the circumstances reported in this study.

Discount Rate

A value of 7 percent was chosen as the discount rate. This is high when compared with real interest rates, but low compared with studies that attempt to elicit discount rates from individuals. For example, Clark, Jones, and Holling (1979) did not find a single decisionmaker with a discount rate of less than 10 percent in their attempts to elicit such values in Canada.

Opening Value and Standard Deviation of the World Price

The opening value of the world price is \$120 per ton, close to the average world price for 1981-85. Choosing an appropriate value for the variability of world price is somewhat more complicated.

Recall that the world price is modeled as a random walk. The series of annual percentage changes in the International Monetary Fund series of U.S. gulf port yellow no. 2 maize prices from 1957 to 1986, deflated by the U.S. wholesale price index, has a standard deviation of 13.7 percent. There are two problems, however. First, variability has been increasing over time. The standard deviation of the series up to 1969 is only 7.3 percent, while the figure since that date is 16.1 percent. This consideration argues for a value higher than the average. The post-1970 figure of 16.1, however, is influenced heavily by the extremely large price increase of 43.0 percent in 1973. The 1973 value is almost twice as large as the next largest price change, and is almost 3.5 standard deviations from the mean. The standard deviation of the price changes from 1970 to 1986, excluding 1973, is only 12.5 percent.

This analysis uses a standard deviation of world price of 14.0 percent. It is inappropriate to give full weight to 1973, since it is such an aberration, but some consideration should be given to the recent increase in variability. The data clearly indicate that the

²⁰ Richard Goldman, personal communication, June 1985.

best figure is between 12 and 16 percent. Fortunately, results of the model are not sensitive to changes in this parameter within that range. Early model runs with constant rather than variable world prices produced optimal policies quite close to those produced with variable world prices. The standard deviation of the fiscal cost is the only result that varies significantly with this parameter.

For the dynamic programming models, as described above, the world price does not behave in a random walk. The seven possible levels of world price are taken to be \$60, \$80, \$100, \$120, \$140, \$160, and \$180 per ton, with the transition probabilities chosen so that the expected values of next year's price are as shown in Table 7. These probabilities correspond roughly with a percentage change standard deviation of 14 percent at the base year world price of \$120 per ton.

Standard Deviation of Production

The standard deviation used in the analysis should be a totally random phenomenon, neither the result of systematic factors in the world nor the result of changing government policies. This makes it difficult to come to an estimate of the number from past history. Since changes in government policy have exacerbated production fluctuations at times, the desired number will be less than the estimate of historical variation.³⁰ The difficulty is compounded by the large differences that result from including or not including the estimate of the 1984/85 crop in the analysis.

Running a linear trend through the maize production figures from 1970/71 to 1983/84 yields a standard error of the estimate of 225,000 tons. At mean production for the time period, this yields a standard deviation of 13.0 percent. On the other hand, if 1984/85 is included, the standard error increases to 306 and the mean is somewhat lower, giving a standard deviation of 17.9 percent.

Some degree of insight into the variability of maize production in Kenya can be gained by examining rainfall data in Kitale district. Kitale is a major exporter of maize to other regions of Kenya and normally has reliable rainfall. Production in 1984/85, however, was only about 50 percent of production the previous year; this shortfall was a significant percentage of the total shortfall of Kenyan production below trend for the year. Since a fairly consistent series of rainfall statistics is available for about twice as many years as the production series used in this study, the rainfall statistics can provide some additional insights into the degree of the rainfall abnormality Kenya experienced in 1984/85.

Table 10 lists rainfall data from Kitale for 1953-84 for the months of April and May, excluding 1956 for which no data are available. April and May are key months for Kitale maize production, as planting cannot be delayed much longer than early April. For 1965-84, the series is the average rainfall at all of the meteorological stations in the district. Data from the Kitale Agricultural Research Station are used for earlier years, as the average series is not available. None of the conclusions reached below are altered significantly by restricting the analysis to 1965-84 data.

Note three points about the series before considering the statistics. First, cumulative rainfall for March and April in 1984 is the lowest on record. While only slightly lower than the figure for 1958, it is almost 20 percent lower than the third lowest figure. In addition, the second, third, and fourth lowest figures are for 1958, 1955, and 1959,

³⁰ For example, most analysts believe that the government was at least partially responsible for the production shortfall in 1979/80 (Kleist, 1985).

Table 10—Kitale rainfall: April and May, 1953-84

Year	Rainfall		April and May ^a
	April	May	
	(millimeters)		
1953	222	172	393
1954	125	160	285
1955	157	88	244
1956	n.a.	n.a.	n.a.
1957	149	137	287
1958	104	97	201
1959	127	125	251
1960	124	182	306
1961	166	145	310
1962	163	142	305
1963	163	144	308
1964	174	148	321
1965	126	133	258
1966	280	80	359
1967	224	260	484
1968	201	95	295
1969	54	229	283
1970	144	136	281
1971	148	118	266
1972	115	168	283
1973	45	210	255
1974	108	147	255
1975	104	210	314
1976	162	246	408
1977	257	153	410
1978	183	160	343
1979	191	165	355
1980	130	244	374
1981	210	152	362
1982	335	270	605
1983	101	326	426
1984	100	97	197
Series Statistics			
Mean (millimeters)	158	166	323
Median (millimeters)	149	152	306
Minimum (millimeters)	45	80	197
Maximum (millimeters)	335	326	605
Standard deviation	62	59	84
Coefficient of skewness	0.79	0.84	1.33

Source: Unpublished data from the Meteorological Department, Kenya.

Note: n.a. means not available.

^a Parts may not add to totals because of rounding.

respectively. The figure for 1984 is 57 millimeters less than the next lowest figure in the last 25 years. Second, there are three sets of years during which rainfall has been virtually constant: 1960-64, 1968-74, and 1978-81. Third, the minimum cumulative rainfall in the period 1975-83 is greater than the maximum cumulative rainfall for 1968-74.

Clearly, more is going on here than random sampling from a stable population, but it is difficult to say more than that. At least, it is hoped that the unusual runs in the series are the result of natural phenomena and not the result of human error.

Considering the statistics, it should be noted that all three series are skewed upward with the mean greater than the median, confirming the generally accepted fact that Kitale rainfall is rarely poor.

These rainfall data tend to support the view that a shortfall as severe as the one in 1984/85 is less likely than 1 in 15, which is the implicit assumption in using the standard error of the estimate from the trend analysis. Thus, a variability around the trend line of about 15 percent seems reasonable, with the component of variation attributable to totally random phenomenon equal to 10-12 percent. As mentioned in the supply response section above, the small amount of supply response will dampen the production instability slightly. Consequently, a figure of 0.10 will be used here.

Own-Price Demand Elasticity

Reference has already been made to the difficulty of doing demand analysis in Kenya. Previous studies (Williamson and Shah 1981; Gerrard 1981) have produced estimates of the own-price demand elasticity for maize ranging from +2.13 to -0.443. It seems best to take a number that is reasonable, given the importance of maize in the Kenyan diet, and use that rather than a number estimated from data that are known to be far from correct. A figure of -0.3 will be used here.

It is important to note that the appropriate number for this analysis is a short-term elasticity and not a long-term number. These two numbers are likely to differ significantly for a staple food in a poor country. The short-run elasticity measures the sensitivity of consumption to immediate price changes. The long-run elasticity measures the sensitivity of consumption to changes in price that remain in effect for a long period of time, allowing consumers to adjust their taste preferences to the price differential.

Equilibrium Price in a Normal Production Year

In the absence of reliable statistics for consumption, the equilibrium price in a normal production year is difficult to estimate. Recent local market prices have been both above and below NCPB official prices (sometimes at the same time in different parts of the country). This indicates that the normal-production-year equilibrium is not far off from the official price. A producer price of \$140 per ton is used here, which translates into a producer price of KSh 189 per 90-kilogram bag at an exchange rate of KSh 15 = US\$1.

Cost of Storage

Storage costs estimated by the government in 1982 were KSh 27.50 per bag per year, exclusive of interest charges (Kenya 1983b). Assuming a 10 percent rate of inflation for two years and a 1985 exchange rate of KSh 15 = US\$1 yields a storage cost of \$2.22 per bag in 1985, or \$24.65 per ton. A figure of \$25.00 per ton is used here.

At this point, then, the problem has been defined, the model set up, and parameters selected. The following chapter presents the results of running the models, including the measurement of trade-offs. Chapter 6 investigates how the price band schemes can be adjusted, given what has been learned from the optimizing model, while Chapter 7 presents conclusions and recommendations.

AN EXAMINATION OF PRICE BAND AND OPTIMAL POLICIES

Results of the Price Band Simulation: Overview

Price band policies were simulated with 5, 10, 15, and 20 percent allowable price variation. Stocks were allowed to vary at 10 different levels between zero and 400,000 tons for each price band. A stock variability of zero implies that year-end stocks do not change; consequently, production variability is buffered only by consumption changes and foreign trade. Results reported in this chapter use an own-price demand elasticity of -0.3 and production variability of 10 percent. Tables 16 and 17 in Appendix 1 present results for a demand elasticity of -0.2 and production variability of 12 percent. Three hundred 10-year cycles were run, with the average values of all the cycles appearing in the graphs and tables.

Figure 4 presents the results graphically. The solid lines are termed "trade-off curves." Price variability is held constant on each curve, with the maximum allowable percent price deviation appearing at the bottom of each line. The marked points on each solid line represent, from top to bottom, increasing levels of stock variability. Each curve individually, then, displays the trade-off between fiscal cost and imports for one particular level of price variability.

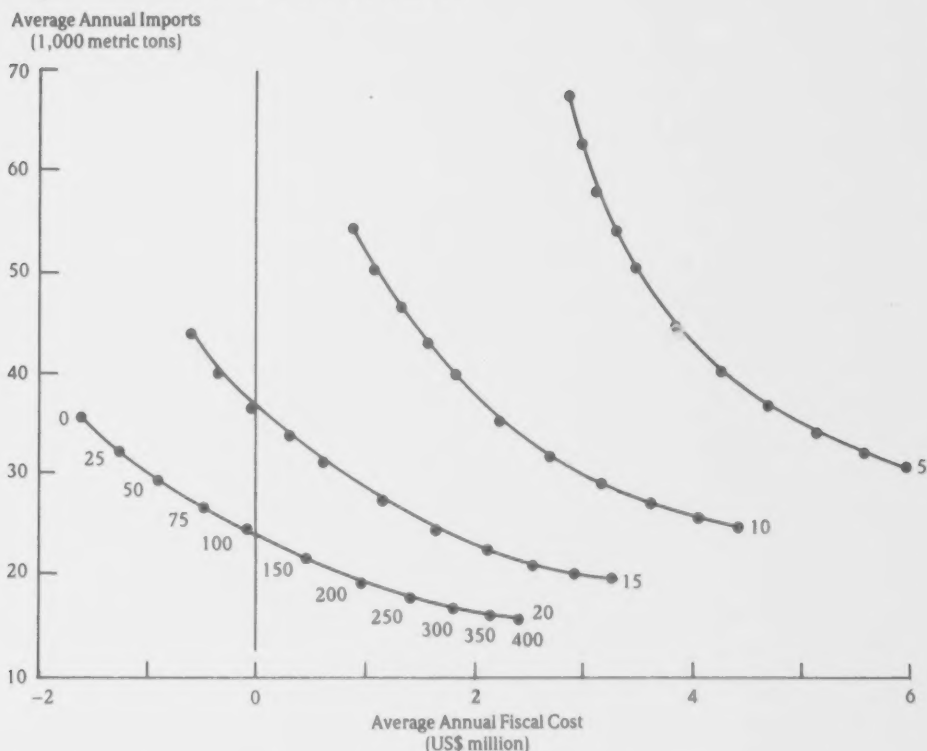
The horizontal axis is the average annual fiscal cost associated with each policy. The vertical axis represents average imports over the 10 years of the simulation. Note that this is different from the average import in importing years. If a price band policy led to total imports of 500,000 tons per 10-year cycle on average, then the figure appearing in the graph would be $500/10 = 50$, whether there was an average of 5 years or only 1 year when imports took place per cycle.

There are several important points to notice about the graph before analyzing why the curves are shaped in this way. First, there are large differences in cost and import levels between the different constant price variability curves. Moving from 5 to 10 percent price variability and holding imports constant decreases the average annual cost by \$2.3 million. While the degree of leverage that price commands over cost decreases as price variability increases, it remains large; even moving from 15 to 20 percent price variability, with constant imports the difference amounts to almost \$2 million annually.

Second, buffer stocks are much more effective at lower levels of price variability than at higher levels. This is apparent from the relative shapes of the constant price variability curves. The 5 percent price variability curve is much steeper than the 20 percent variability curve, implying that increasing stock variability "buys" a large amount of decreased imports for relatively little additional fiscal cost at that price level. Increasing stock variability from zero to 100,000 tons at this price level costs about \$30,000 annually per 1,000-ton decrease in average imports. On the other hand, increasing stock variability by the same amount when prices vary by 20 percent costs more than four times as much. Reasons for this are discussed in the next section.

The results are presented numerically in Table 11. The first two columns of the table list the percent price band and the stock variability. Column 3 lists the standard

Figure 4—Price band trade-off curves



Note: The number at the bottom of each line is the maximum allowable percentage deviation from the target price.

deviation of price that corresponds to the percent price variability.³¹ Columns 4 and 5 are the coordinates on the vertical and horizontal axes in the figures, the average annual imports and the average annual cost. The standard deviation of the fiscal cost is presented in column 6, while the mean closing stock level at the end of each 10-year cycle is presented in column 7. Columns 8 through 11 list the four components of fiscal cost: returning the stock level to 100,000 tons at the end of each cycle, physical storage costs, losses from trade in the domestic market, and losses from trade in the international market. All monetary figures are in terms of average annual losses; that is, a negative number represents a profit.

The domestic and foreign trade accounts are simply revenues from sales minus expenditures on purchases in each market. The foreign trade account therefore shows the gains or losses in foreign exchange of the different policies. Since it is possible that

³¹ Actually, the number in column (3) is the square root of $\sum (P_t - P^*)^2 / (N - 1)$. This will differ from the standard deviation of price if the mean of price differs from P^* . This number is called "standard deviation of price" throughout the text.

Table 11—Price band results

(1) Price Band	(2) Stock Variability	(3) Standard Deviation of Price	(4) Imports	(5) Average Annual Fiscal Cost	(6) Standard Deviation of Cost	(7) Average Stock Level	Components of Fiscal Cost			
							(8) Replace Stock Charges	(9) Storage Costs	(10) Domestic Trading Losses	(11) Foreign Trading Losses
(percent)	(1,000 metric tons)	(US\$/metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)			(US\$ million)	
5	0	6.7	67.5	2.88	3.23	0	0.87	0.00	-0.17	2.18
5	25	6.7	62.5	2.98	3.24	13	0.76	0.34	-0.17	2.05
5	50	6.7	58.0	3.12	3.26	26	0.65	0.69	-0.17	1.96
5	75	6.7	54.0	3.29	3.31	38	0.53	1.03	-0.17	1.90
5	100	6.7	50.4	3.49	3.37	51	0.42	1.37	-0.17	1.87
5	150	6.7	44.6	3.85	3.51	77	0.20	1.99	-0.17	1.82
5	200	6.7	40.2	4.25	3.70	103	-0.02	2.59	-0.17	1.85
5	250	6.7	36.8	4.69	3.92	127	-0.24	3.16	-0.17	1.93
5	300	6.7	34.2	5.14	4.17	152	-0.45	3.69	-0.17	2.07
5	350	6.7	32.2	5.56	4.43	176	-0.66	4.17	-0.17	2.21
5	400	6.7	30.7	5.96	4.71	199	-0.86	4.60	-0.17	2.39
10	0	12.8	54.9	0.88	2.86	0	0.87	0.00	-1.01	1.02
10	25	12.8	50.4	1.07	2.88	13	0.76	0.35	-1.01	0.97
10	50	12.8	46.5	1.30	2.94	25	0.65	0.70	-1.01	0.96
10	75	12.8	43.0	1.55	3.01	38	0.54	1.05	-1.01	0.97
10	100	12.8	40.0	1.81	3.09	51	0.42	1.40	-1.01	1.00
10	150	12.8	35.3	2.24	3.27	77	0.20	2.00	-1.01	1.04
10	200	12.8	31.8	2.71	3.50	101	-0.01	2.58	-1.01	1.15
10	250	12.8	29.2	3.18	3.76	126	-0.22	3.12	-1.01	1.30
10	300	12.8	27.1	3.62	4.03	149	-0.43	3.60	-1.01	1.46
10	350	12.8	25.7	4.04	4.32	172	-0.63	4.03	-1.01	1.65
10	400	12.8	24.7	4.41	4.62	195	-0.83	4.41	-1.01	1.84
15	0	18.4	43.9	-0.61	2.58	0	0.87	0.00	-1.53	0.05
15	25	18.4	40.1	-0.34	2.63	13	0.76	0.36	-1.53	0.07
15	50	18.4	36.7	-0.03	2.71	26	0.65	0.72	-1.53	0.12
15	75	18.4	33.7	0.29	2.80	39	0.53	1.08	-1.53	0.20
15	100	18.4	31.2	0.62	2.93	51	0.43	1.44	-1.53	0.28
15	150	18.4	27.5	1.13	3.15	76	0.21	2.03	-1.53	0.41
15	200	18.4	24.7	1.63	3.41	100	0.00	2.57	-1.53	0.58
15	250	18.4	22.7	2.10	3.70	124	-0.20	3.06	-1.53	0.77
15	300	18.4	21.2	2.54	4.00	146	-0.40	3.49	-1.53	0.97
15	350	18.4	20.3	2.93	4.29	169	-0.60	3.87	-1.53	1.18
15	400	18.4	19.7	3.26	4.60	189	-0.77	4.18	-1.53	1.37
20	0	23.5	35.3	-1.63	2.38	0	0.86	0.01	-1.86	-0.64
20	25	23.5	32.0	-1.27	2.45	14	0.75	0.39	-1.86	-0.55
20	50	23.5	29.1	-0.89	2.55	27	0.64	0.77	-1.86	-0.44
20	75	23.5	26.5	-0.50	2.69	39	0.53	1.14	-1.86	-0.31
20	100	23.5	24.3	-0.10	2.85	51	0.42	1.51	-1.86	-0.17
20	150	23.5	21.4	0.44	3.09	75	0.21	2.07	-1.86	0.02
20	200	23.5	19.2	0.95	3.36	99	0.01	2.57	-1.86	0.23
20	250	23.5	17.8	1.41	3.65	121	-0.18	3.01	-1.86	0.45
20	300	23.5	16.8	1.81	3.94	142	-0.37	3.38	-1.86	0.66
20	350	23.5	16.2	2.15	4.25	161	-0.53	3.68	-1.86	0.86
20	400	23.5	15.9	2.43	4.53	179	-0.68	3.93	-1.86	1.04

more physical units could be bought than sold in a market, a profit (loss) alone does not imply that the average selling price is higher (lower) than the average buying price.

Components of Cost for Price Band Schemes

The components of fiscal cost given in Table 11 are useful for analyzing the reasons for the responsiveness of fiscal cost to price variability and stock variability. Replacement costs are straightforward, being related directly to the mean closing stock level. Storage costs are somewhat more complicated. Note that for stock variability levels above 200, storage costs decrease with increasing price flexibility, but for higher levels of stock variability the decrease is larger proportionately than the corresponding change in mean stock level. In addition, the storage costs for 150,000 tons and below increase slightly with increasing price variability.

Both of these outcomes are the result of the opening stock level of 100,000 tons. The storage costs are the sum of the average closing stock level in each year multiplied by the cost per ton. For the 200,000-ton level of stock variability, the opening stock level is quite close to the average stock level; thus the proportionate change in storage costs is close to the change in closing mean stock level. On the other hand, the 300,000- and 400,000-ton stock variabilities generally have lower than average stock levels for the first few years of the simulation, and the stock level will remain low for more years when price variability is higher (since the government intervenes less often). The corresponding effect on the other side causes storage costs for lower levels of stock variability to be higher when prices are more flexible. Thus the storage costs differ from a straightforward multiplication of closing stock times average cost because the mean stock level in early years of the cycles differs from the mean stock level at the end of the cycles.

Domestic trading gains are determined by the difference between buying price and selling price and the amount of government intervention. With higher levels of price flexibility, the government makes more money whenever it buys one year and sells the next.

The foreign exchange account is the most complex. Recall that this account is the cost of imports (including aid) minus the cost of exports. This account is particularly difficult to understand for two reasons: the volume of imports may differ considerably from the volume of exports, and small volumes of exports are sold at a premium.

There are several characteristics of the foreign exchange account to notice. First, with 20 percent price flexibility, foreign exchange losses increase with increased stock variability. This result holds true for the higher levels of stock variability at 5, 10, and 15 percent price flexibility, but in each case foreign exchange losses decrease for the lowest levels of stock variability. Nevertheless, in every case foreign exchange losses are larger for the *lowest* level of imports—that is, for the highest level of stock variability—than they are for the *highest* level of imports. Thus, at some point for each level of price variability, reducing imports implies *losing* foreign exchange.

This conundrum is best understood by examining the relationship between average closing stock levels, imports, and exports. For the price band regimes, the width of the price band alone determines the government purchases. Consequently, the same amount is bought and sold in the domestic market regardless of the stock triggers for imports and exports. So alternative policies that differ only in stock variability would have equal net domestic purchases over any time period; closing stock levels, therefore, can differ only because of differences in net imports. This implies that over the same sequence of production years, the total volume imported minus the total volume ex-

ported minus the closing stock level is the same for all policies with the same price variability. Since increasing stock variability increases closing stocks and decreases imports, it must decrease exports by the sum of those two amounts, thereby decreasing export volume by a larger amount than import volume. Since the marginal decline in imports that results from increasing stock variability decreases as stock variability becomes large, while the increase in stock level is close to uniform, the relative effect on net export volumes increases.

If the difference between export and import parity were slight, the foreign-trade account would always lose money when stock variability increases. Since import parity is in fact considerably higher than export parity, this account begins to lose money with increasing stock variability only when the ratio of the decrease in export volume to the decrease in import volume is greater than the ratio of import parity price to export parity price.³² This does not occur until stock variability reaches about 150,000 tons when the price band is 5 percent, but occurs at all levels of stock variability when the price band is 15 or 20 percent.

So at this point the components of cost of the price band schemes have been analyzed. Trade-offs between government objectives as measured by the price band schemes are presented in the next chapter, after an examination of the results of the dynamic programming runs.

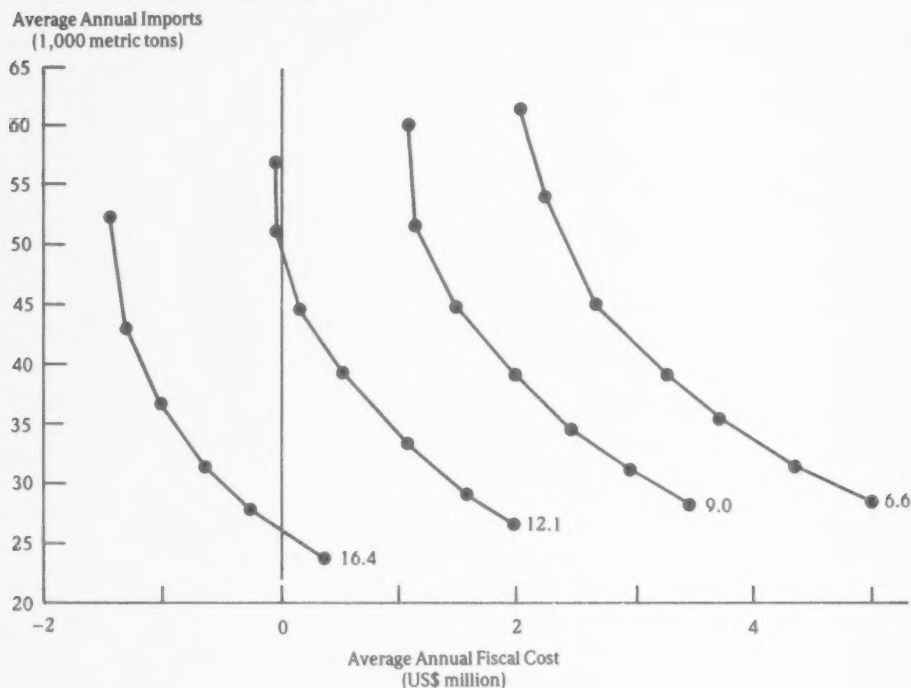
Optimization Results: Overview

Results of the dynamic programming policies are presented in Figure 5 and Table 12. For sensitivity analysis, similar tables for a demand elasticity of -0.2 and production instability of 12 percent are presented in Appendix 1, Tables 18 and 19. Each line of the tables displays the results of an optimization run with a different objective function. The producer/consumer surplus model appears at the bottom of Table 12. All other runs differ only in the weights applied in the objective function to the three different objectives. The weights have been chosen so that the standard deviation of price is constant for four sets of weight combinations. An attempt was made to make the average imports exhibit approximately the same range as occurs in the price band simulations.

As stated above, dynamic programming produces a set of optimal values of the policy variables for each possible combination of production, world price, and opening stock. These discrete policies are then interpolated to make them continuous, and the interpolated policies simulated in the same way as the price band policies are simulated. Thus the results for the optimal policies are directly comparable with those for the price band policies. Figure 5 differs from Figure 4 only in that the number at the base of each line in the price band figures is the maximum allowed percentage deviation in price; in the optimal policy figures, the number is the standard deviation of the price, which will be termed the level of price variability. The corresponding number for the price band schemes can be read from Table 11.

³² This statement is exactly true if import and export parity prices are constant across different levels of stock variability. In actuality, the situation is slightly more complicated, since average export and import prices also vary with increasing stock variability, as higher stock levels lead to less food aid and a change in the proportion of exports that are sold at a premium. But these price changes are relatively small (5-7 percent between stock variabilities of 0 and 400,000 tons).

Figure 5—Optimal policy trade-off curves



Note: The number at the bottom of each line is the standard deviation of price in dollars per ton.

The price variability levels in Figures 4 and 5, however, are not identical. Consequently, Figure 6 presents price band trade-off curves for which the levels of price variability are the same as in Figure 5. Table 20 in Appendix 1 presents the results for these price band policies numerically. Figure 7 displays a price band and an optimal policy with the same standard deviation of price for direct comparison.

The first two columns differ between the tables for price band policies (Table 11 and appendix Tables 16, 17, and 20) and the tables for the optimal policies (Table 12 and appendix Tables 18 and 19). In the price band tables these are the percent price band and the maximum stock variability; for the optimal policies, these columns are the weights in the objective function on price stability and imports, respectively. Recall that fiscal cost, being the numeraire of the objective function, is not explicitly weighted; its weight results from changes in the combined level of the other two weighting parameters. For example, the weight on fiscal cost would be halved implicitly by moving from a weighting system of $a = 10$ and $b = 40$ to $a = 20$ and $b = 80$ (where "a" is the weight on price stability and "b" is the weight on imports).

The producer/consumer surplus maximization model describes the free market solution with no government intervention. With an open economy, average stock carry-out is virtually zero; trade is used rather than stocks to stabilize price. Average annual fiscal cost in this case is private sector "cost" (column 5 in the tables for price band and optional policies). Since the figure is negative, profits of about \$3.7 million

Table 12—Optimal policy results

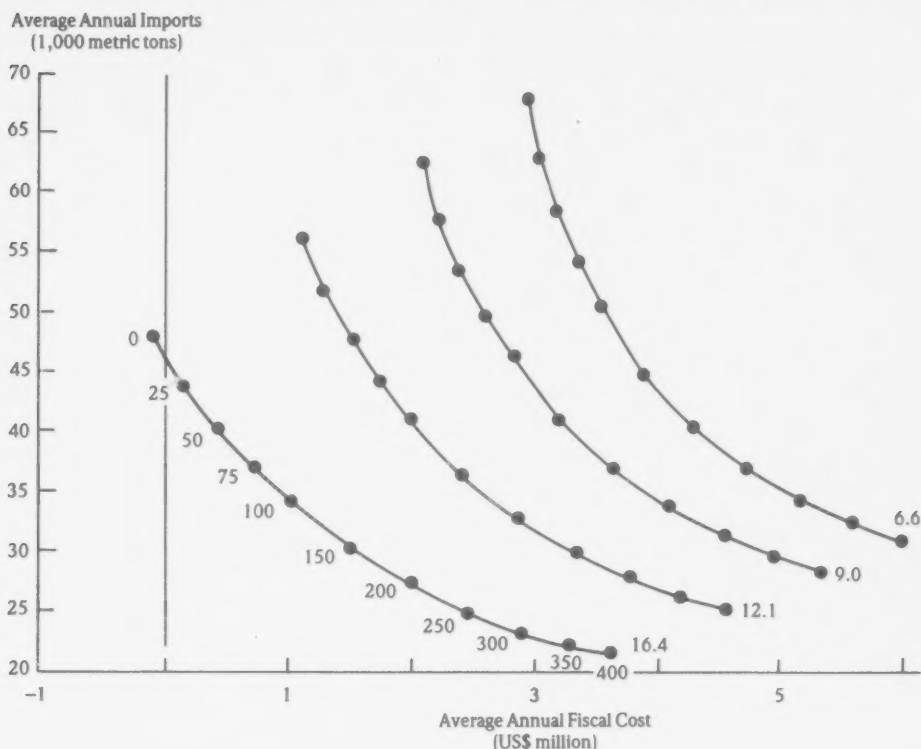
(1)	(2)	(3)	(4)	(5)	(6)	(7)	Components of Fiscal Cost			
							(8)	(9)	(10)	(11)
Price Stability Weight	Import Weight	Standard Deviation of Price	Imports	Average Annual Fiscal Cost	Standard Deviation of Cost	Average Stock Level	Replace Stock Charges	Storage Costs	Domestic Trading Losses	Foreign Trading Losses
		(US\$/ metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)		(US\$ million)		
31.5	0	6.6	61.3	2.03	2.72	36	0.56	0.92	-1.26	1.82
37.3	50	6.6	54.2	2.24	3.08	60	0.35	1.44	-0.62	1.07
40.0	103	6.6	45.0	2.68	3.44	91	0.08	2.14	-0.00	0.48
44.6	149	6.6	39.2	3.27	3.73	117	-0.15	2.76	0.27	0.38
49.0	185	6.6	35.6	3.73	4.03	136	-0.32	3.21	0.55	0.28
53.5	241	6.6	31.7	4.38	4.31	163	-0.54	3.76	0.88	0.28
58.0	287	6.6	28.8	4.99	4.54	184	-0.73	4.24	1.13	0.35
22.0	0	9.0	59.9	1.09	2.39	31	0.60	0.81	-2.08	1.76
23.3	39	9.0	51.7	1.14	2.68	48	0.45	1.20	-1.25	0.75
26.5	80	9.0	45.3	1.48	3.04	67	0.28	1.69	-0.65	0.16
29.2	120	9.0	39.3	1.99	3.33	95	0.05	2.23	-0.15	-0.13
32.0	160	9.0	34.6	2.48	3.62	115	-0.13	2.71	0.27	-0.37
34.9	200	9.0	31.3	2.96	3.89	132	-0.28	3.13	0.52	-0.41
37.5	240	9.0	28.4	3.46	4.15	148	-0.42	3.52	0.85	-0.49
14.2	0	12.1	56.9	-0.04	2.06	24	0.66	0.68	-2.91	1.54
15.3	28	12.1	50.7	-0.03	2.29	36	0.56	0.93	-2.12	0.60
17.0	60	12.1	44.7	0.13	2.56	52	0.42	1.26	-1.48	-0.06
18.8	95	12.1	39.4	0.50	2.90	66	0.30	1.65	-0.99	-0.46
20.9	140	12.1	33.4	1.05	3.20	89	0.10	2.15	-0.29	-0.90
22.9	180	12.1	29.2	1.55	3.48	109	-0.08	2.60	0.08	-1.05
24.9	220	12.1	26.6	1.99	3.72	125	-0.22	2.95	0.53	-1.28
8.9	0	16.4	52.3	-1.46	1.91	16	0.73	0.49	-3.75	1.07
10.4	40	16.4	43.1	-1.33	2.18	31	0.60	0.84	-2.49	-0.27
11.7	80	16.4	36.6	-1.03	2.46	45	0.47	1.16	-1.69	-0.98
13.0	120	16.4	31.5	-0.65	2.80	62	0.33	1.54	-1.03	-1.49
14.3	155	16.4	27.8	-0.26	3.00	77	0.20	1.86	-0.47	-1.85
15.6	200	16.4	23.9	0.31	3.27	94	0.05	2.29	0.09	-2.11
Producer/consumer surplus model		29.0	50.0	-3.69	2.25	3	0.80	0.09	-5.26	0.64

annually are made. Larger domestic profits are offset to some extent by small losses in the other three accounts. The degree to which prices fluctuate, however, is much higher than the historical level, as the standard deviation of price is \$29.00 per ton. With fluctuations in the international price and the large difference between import and export parity, trade alone is not able to stabilize price sufficiently. Nevertheless, virtually no storage takes place since the private sector cannot usually expect to profit from storage. Thus there is a clear rationale for some type of government intervention to stabilize price.

Relative Costs of Optimal and Price Band Policies

Tables 11 and 12 and Figure 7 show clearly that on average the optimal policies are less expensive to operate, holding price variability and average imports constant. The broken lines on the graph in Figure 7 show that when average imports are 40,000 tons, the optimal policy costs on average 1.6 million dollars annually less than the price band policy.

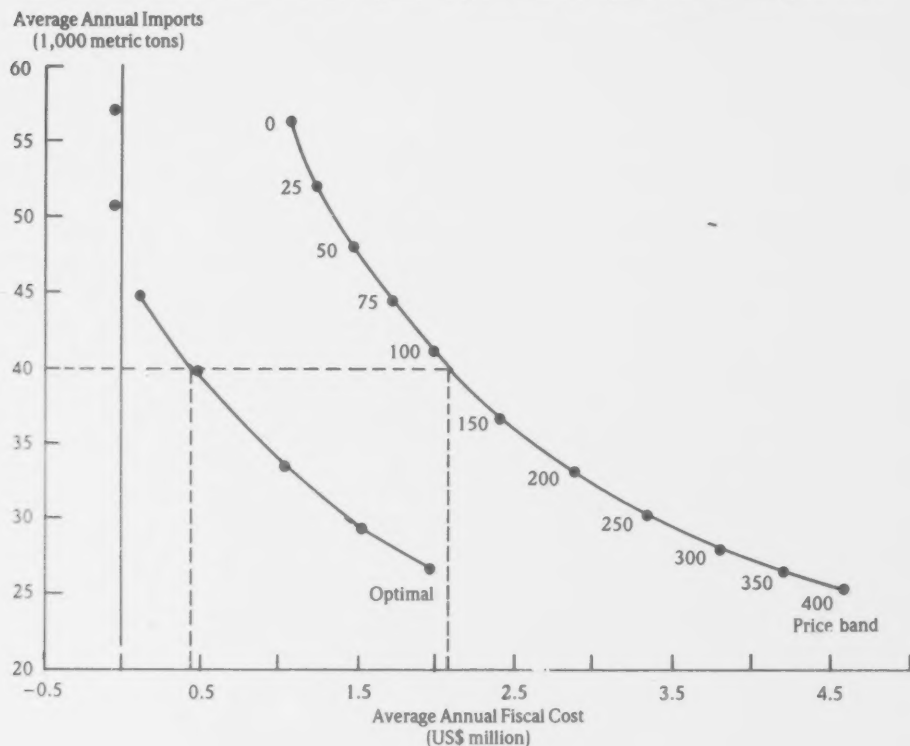
Figure 6—Price band trade-off curves for comparison with optimal



Note: The number at the bottom of each line is the standard deviation of price in dollars per ton.

Average cost differentials, however, may not be statistically significant if the standard deviation of the difference in cost is large. Consequently, costs for each of the 300 10-year cycles for one of the optimal policies were compared cycle by cycle with costs for one of the price band policies. The policies were chosen so that both price variability and imports are equal on average. The chosen optimal policy is the third point from the top on the optimal curve in Figure 7, with a price weight of 17 and an import weight of 60, resulting in average imports of 44,700 tons and a standard deviation of price of \$12.10. The chosen price band scheme is the fourth point from the top in the figure (stock variability of 75). The average difference in cost is about \$1.6 million annually, with a standard deviation of 1.1. The distribution of the price differential is skewed upward, however, as the median difference is \$1.4 million. In the worst case of the 300 cycles for the price band scheme, the optimal policy costs \$5.2 million less, which is 3.2 standard deviations from the mean. In the best case for the price band schemes, the optimal policy costs \$40,000 more, which is only 1.4 standard deviations from the mean. The price band policy actually costs less than the optimal policy in 17 out of the 300 cycles, but in each of these cases the difference is small. Thus the difference in cost is significant.

Figure 7—Price band versus optimal policies for price variability of 12.1



The first step in gaining an understanding of these cost differences is to examine the differences in the components of cost. This is followed by a study of the differences in policy structure.

Optimization Results: Components of Cost

In examining the components of cost for the optimal policies, the replacement-of-stock component is directly related to closing stocks, as it is for the price band policies. Storage charges are actually simpler than in the price band schemes, being related almost directly to the mean closing stock level. Since the optimal policies produce the best level of each of the control variables for every possible stock level, the system is not in a state of disequilibrium at the start, as was the case for some of the price band policies.

Domestic trade looks considerably different than it does under the price band policies. This account actually loses money if the government has a relatively strong preference for reducing imports or stabilizing prices. This is not a case of the marketing board buying maize at a high price and selling it at a low price. Rather, the optimal policies adjust to government preferences by buying more than they sell domestically. This raises prices on average—which the government does not want—but also results

in higher average stock levels, thereby improving the government's ability to cushion production fluctuations from stocks rather than from imports. This is advantageous given some patterns of relative preferences for the three objectives. For the price band schemes, average prices cannot be raised no matter what the preferences of the government are, since the policies are constrained to buy and sell approximately equal quantities domestically.

As with the price band schemes, the foreign exchange account is the most difficult to understand. One trend is clear: as the weight on price stability increases, the foreign exchange account loses more money. This is true across all levels of weights, elasticities, and production variabilities. As mentioned above, the government's preference for stable prices acts as a constraint that keeps the policy from responding flexibly to world price or stock level. The government must import more at unfavorable prices than previously, in addition to holding more stock and thus exporting less.

The foreign exchange consequences of increasing the desire of the government to minimize imports are less clear. The effect on domestic trade, noted above, is to exchange increased price stability in surplus years for decreased stability in deficit years, thus holding average price variability constant. This adjustment on the domestic side complicates the simple relationship between stocks, imports, and exports that explains the foreign exchange account of the price band schemes.

It is important to distinguish methods being used to decrease imports in the optimal and price band schemes. For the price bands, the mechanism is to use one tool, stock variability, which is subject to decreasing returns to scale and which actually decreases exports more than imports. For the optimal policies, the penalty on imports is direct, and thus in general the effect on imports is stronger than the effect on exports; the tables therefore show decreasing foreign exchange losses (or increasing profits) in the trade account as the weight on imports increases. It is not until the model is constrained by high weights on both price stability and imports that the mechanism described above for the price band schemes becomes dominant, with exports declining more than imports because of an increase in stockholding.

So the cost components of the optimal policies are quite different from those of the price band schemes. These result from differences in the way the two types of policies respond to production, world price, and opening stocks. An examination of these differences is conducted in the next section.

Differences Between Price Band and Optimal Policies

The best way to gain an intuitive understanding of the differences between price band and optimal policies is, first, to examine how the policies differ in a particular cycle of state variables; second, to examine the average relationships between state variables and control variables under the two policies. These will be discussed in turn.

Table 13 presents the results for a price band policy and an optimal policy that have similar values for imports and price variability on average. During the 300 10-year cycles of the simulation, both policies yield a standard deviation of price of \$12.10 and average imports slightly greater than 44,000 tons. But as the table shows, in any one year the policies may produce very different results.

Since the random number generator for this cycle has produced high world prices, the optimal policy imports less than the price band policy (on average, with these two specific policies imports will be equal). The optimal policy virtually breaks even over these 10 years, while the price band policy loses about \$1.4 million annually on average. The difference between the policies, however, is not spread out evenly over every

Table 13—Simulation of price band and optimal policies: one cycle

Year	Production	World Price	Net Purchases	Domestic Price	Net Imports	Closing Stocks	Annual Cost ^a	Sum of Costs
	(1,000 metric tons)	(US\$/metric ton)	(1,000 metric tons)	(US\$/metric ton)	(1,000 metric tons)	(1,000 metric tons)	(US\$ million)	
Price band policy ^b								
0	...	...	...	...	...	100	...	...
1	2,047	133	-139	154	39	0	-13.83	-13.83
2	2,351	118	37	127	0	36	5.20	-8.63
3	2,306	125	0	129	0	36	0.79	-7.84
4	2,323	144	9	127	0	44	1.79	-6.06
5	2,622	161	308	127	-276	75	3.69	-2.37
6	2,836	154	522	127	-521	75	5.63	3.25
7	1,754	181	-432	154	357	0	-1.86	1.39
8	2,432	169	118	127	-42	75	6.06	7.45
9	2,349	114	35	127	-34	75	1.54	8.99
10	2,142	124	-44	154	0	31	-3.26	5.73
Replace stock adjustment	...	...	...	...	...	...	4.50	10.23
Average annual cost	...	...	...	...	...	...	...	1.36
Optimal policy ^c								
0	...	...	...	...	...	100	...	...
1	2,047	133	-140	154	40	1	-13.51	-13.51
2	2,351	118	79	136	-74	6	2.40	-11.16
3	2,306	125	43	137	-44	5	0.65	-10.46
4	2,323	144	61	138	-66	0	-0.76	-11.22
5	2,622	161	313	129	-182	132	14.91	3.69
6	2,836	154	500	124	-486	146	6.80	10.49
7	1,754	181	-384	166	238	0	-18.04	-7.55
8	2,432	169	160	136	-133	27	0.94	-6.61
9	2,349	114	73	135	-60	39	2.91	-3.70
10	2,142	124	-48	153	8	0	-3.18	-6.87
Replace stock adjustment	...	...	...	...	...	...	6.53	-0.35
Average annual cost	...	...	...	...	...	...	...	-0.05

^a Annual costs include a discount factor of 7 percent per year beginning in year 2.

^b The price band policy has maximum price flexibility of 9.37 percent and stock variability of 75,000 tons.

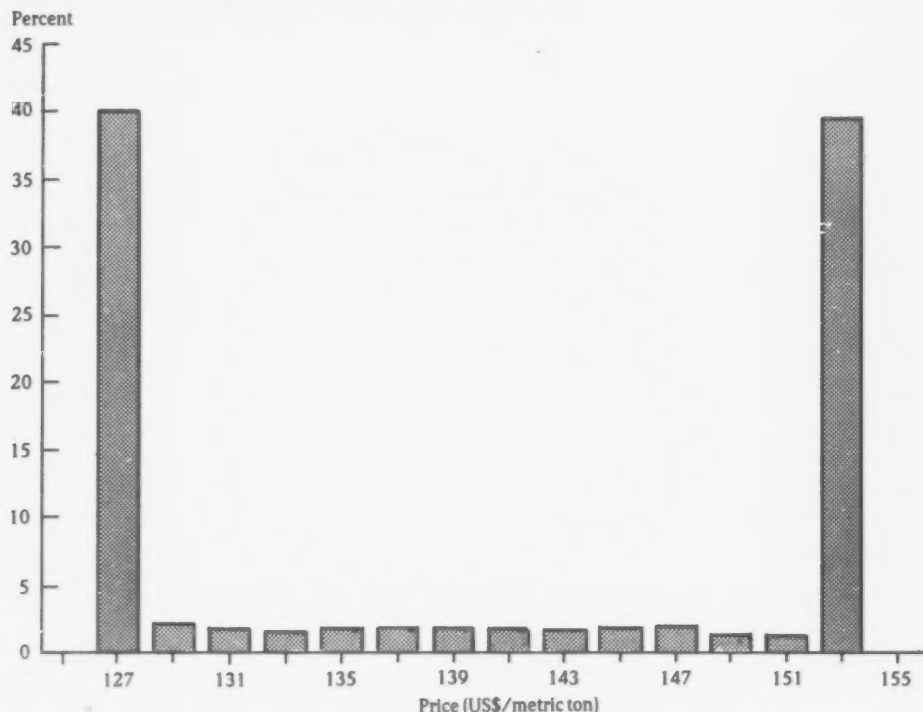
^c The optimal policy has a price weight of 17 and an import weight of 60.

year; for these 10 years, the optimal policy costs considerably less four times, the two are almost equal three times, and the price band policy costs less three times.³³ However, it is partly because the price band policy costs less in years 5 and 6 (because it exports more and stores less) that it is so far inferior to the optimal policy in year 7. The policies cannot be compared except in a dynamic context.

Although the price variability levels are equal on average for these two policies, the distribution of prices is strikingly different. For the 10 years in the table, the price band policy is at either the low or high extreme nine times, while the optimal policy prices are more spread out. Figures 8 and 9 present frequency histograms of price for all 3,000 simulated years (300 10-year cycles), using the same two policies as in Table 13. Note that the scale is different in the two histograms. The price band histogram shows that in 80 percent of the years the price is at either the maximum or minimum allowed value. The optimal policy is also bimodal, but much more dispersed. Although the price component of the objective function is equal for these two policies, if govern-

³³ Annual comparisons are obscured by the lack of any adjustment for differences in closing stock level. The adjustment is made at the end of the tenth year.

Figure 8—Price frequencies: price band policy



Note: Price variability = 12.1, demand elasticity = -0.3, production variability = 0.10.

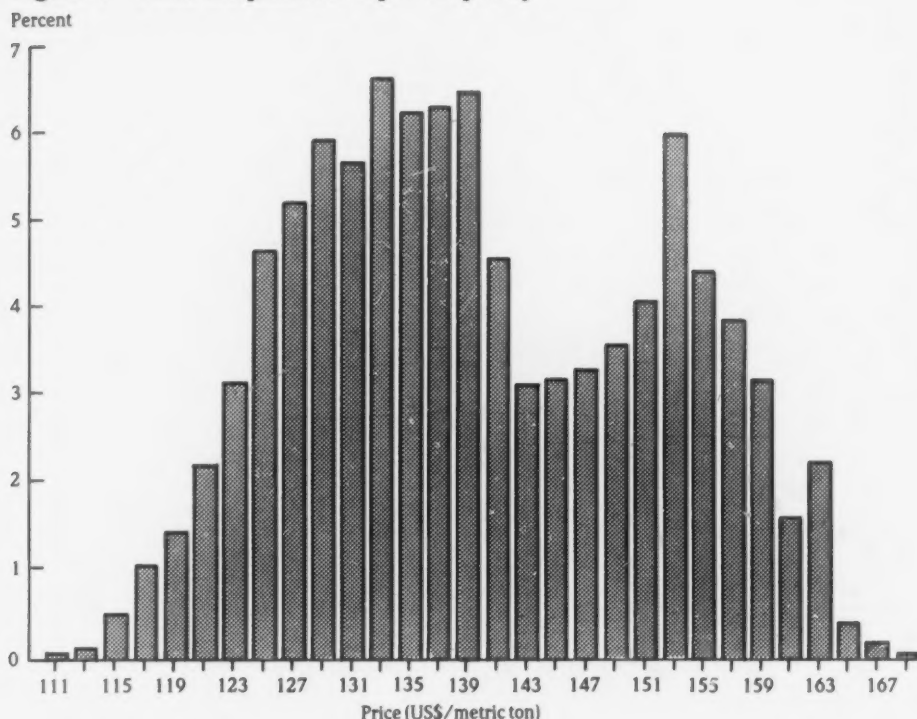
ment preferences have not been modeled accurately by the objective function, it is quite possible that one distribution of prices would be preferred over the other.

Government net purchases determine the domestic price. Net purchases and trade are the two control variables for the stockholding agency. For the price band policies the decisions are sequential, with the trade decision following the net purchases decision. The optimal policy decision will also be treated as sequential in order to facilitate the comparison with the price band policy, although in the optimization process the two are chosen simultaneously.

Figure 10 shows the relationship between production and net purchases for a price band rule that results in a price variability of \$12.10 and an optimal policy with the same price variation. Unlike the price band schemes, the net purchases in the optimal policies are sensitive to opening stocks, world price, and the objective function weights; the optimal relationship shown is for opening stocks of zero and a world price of \$100.00 per ton for the same objective function weights considered above (price weight of 17, import weight of 60). As mentioned in Chapter 3, the price band policy has three linear sections, with slopes of one, zero, and one. The optimal policy, on the other hand, is a smooth curve that is close to being linear.

The two curves are close together with the exception of the rare case of very high production. It would be surprising if differences of the magnitude shown on the graph

Figure 9—Price frequencies: optimal policy

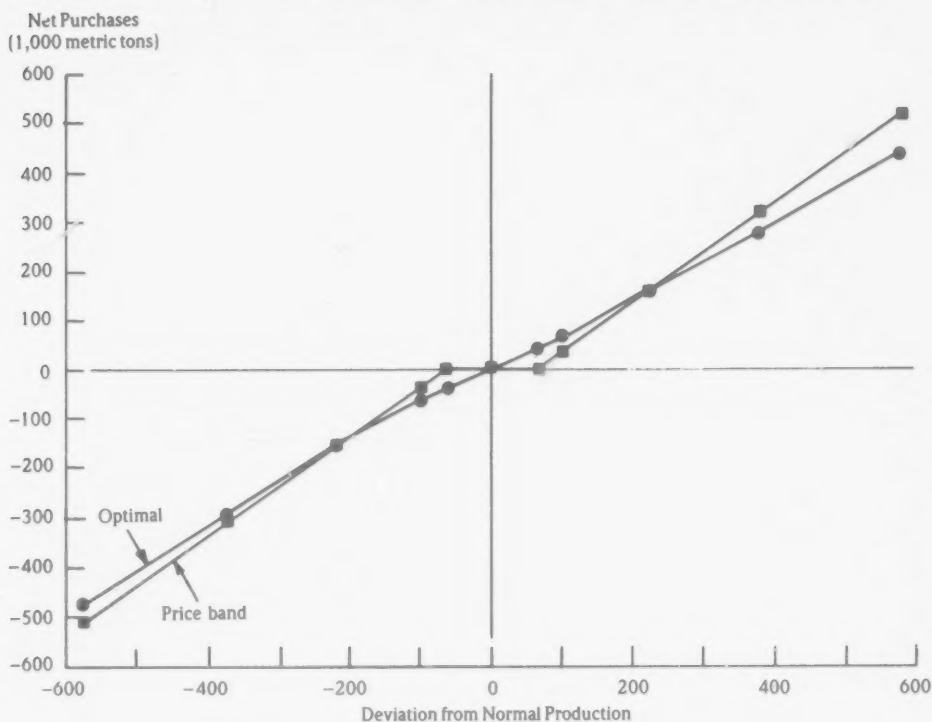


Note: Price variability = 12.1, demand elasticity = -0.3, production variability = 0.10.

produced such large differences in cost. But consider Figure 11, which displays the same case as Figure 10 except that opening stocks are 400,000 tons rather than zero. The price band curve does not change from one figure to the next since purchases are not sensitive to opening stocks in these schemes. But the optimal policy has changed considerably, leading to large differences between the curves in the frequent case of production being slightly below normal. This confirms that the major problem with price band schemes is the absence of flexibility to opening stocks and other state variables.

The way that the optimal policies respond to changes in government preferences is displayed in Figure 12. The curve displayed with diamonds and labeled "base" is the case considered above: a price weight of 17 and an import weight of 60, yielding price variability of \$12.10 and average imports of 44,700 tons. This will be termed policy 1. The curve displayed with bullets and labeled "low imports" has a price weight of 24.9 and an import weight of 220. This policy, called policy 2, produces the same price variability as policy 1, but average imports of only 26,700 tons. The third curve, displayed with squares and labeled "low price variability" is called policy 3. It displays results for a price weight of 40 and an import weight of 103, yielding virtually the same level of imports as policy 1, but price variability of only \$6.60 per ton. The displayed curves are all for a world price of \$100.00 and opening stocks of 100,000 tons.

Figure 10—Net purchases: price band versus optimal for opening stock = 0

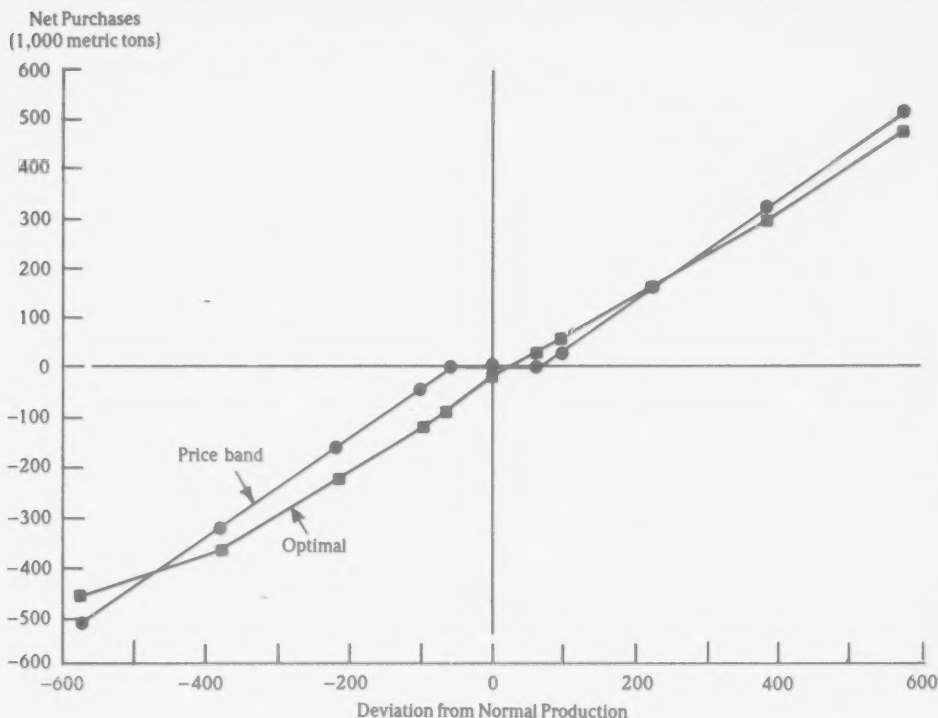


Note: Demand elasticity = -0.3 , production variability = 0.10 , and world price = US\$100.

All of the policies have the same net purchases when production is between its mean value and 100,000 tons less than the mean, with each policy making up the entire difference between actual and normal production in such years. With these exceptions, however, the curve for policy 2 is always above the curve for policy 1, implying that more is bought in high production years and less is sold in low production years. Such a policy clearly leads to lower imports. The curve for policy 3, on the other hand, is below the policy 1 curve in low production years and above it in high production years. There are thus more purchases in high production years and more sales in low production years, leading to greater price stability. The larger stockholdings gained through higher purchases, however, do not reduce imports on average, because larger amounts of grain are required for sale in deficit production years.

Once net purchases are determined, the stockholding agency is left with a quantity equal to opening stocks plus net purchases, which will be termed "available supply." Imports and aid are brought in to make up the deficit exactly if the available supply is negative. Positive available supply can be either stored or exported. The relationships between available supply, closing stocks, and exports are displayed in Figure 13 for

Figure 11—Net purchases: price band versus optimal for opening stock = 400



Note: Demand elasticity = -0.3 , production variability = 0.10 , and world price = US\$100.

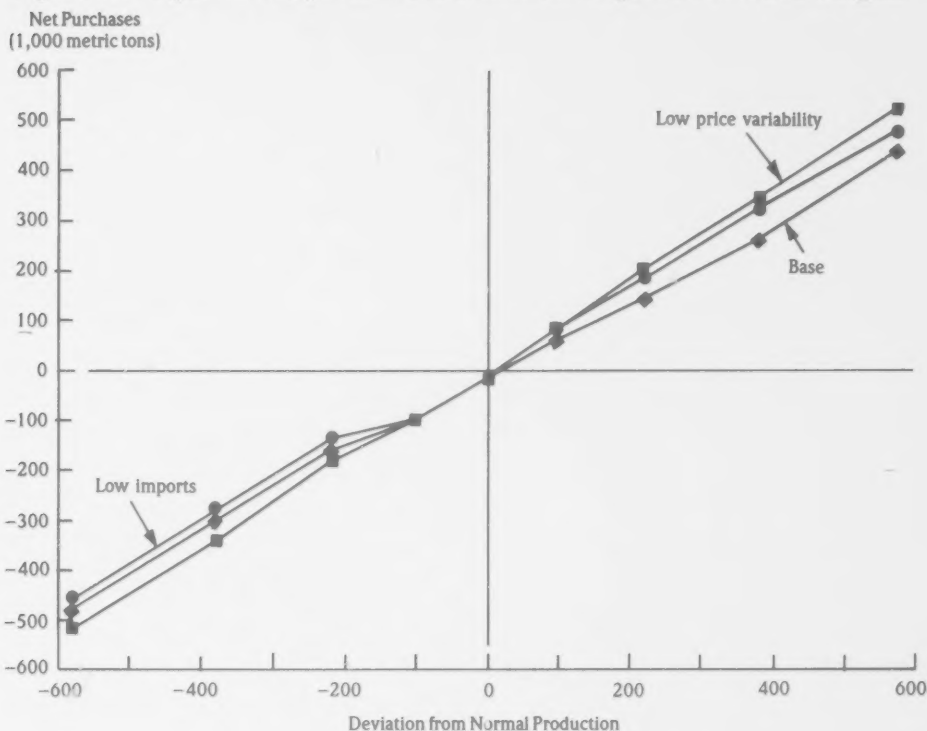
policy 1 from the net purchases analysis: world price equal to \$100.00, price weight equal to 17, and import weight equal to 60.

Each curve has three segments that are almost linear. The stock curve rises with a slope of 0.5 until stocks reach 100, then rises with a slope of 1.0 until stocks reach 340, and then flattens out. Since whatever is not held as a stock is exported, the export curve also has three sections, with slopes of 1.0 minus the slope of the stock curve. It is clear that the value of holding stocks when available supply is low is approximately equal to the value of exporting at the prevailing premium price; when the export premium decreases at 100,000 tons of exports, stocks absorb all additional supply until the marginal value of holding additional stocks is smaller than the export price without the premium.

This stock curve for a world price of \$100.00 is contrasted to the stock curve for a world price of \$140.00 and the price band/buffer stock curve in Figure 14. Of course, additional curves could be included for price band policies with different levels of stock variability, but the shape would be the same.

The two optimal policy curves are similar in shape, with two important differences. First, the maximum stock level is much lower for a world price of \$140.00 per ton

Figure 12—Optimal net purchases for different objective function weights



than it is for a world price of \$100.00. This reflects the increased opportunity cost of stocks with higher world prices. Also, at higher world prices, 1 ton of exports is worth a larger fraction of a ton of future imports, since with higher world prices and a constant price differential the ratio of export parity to import parity increases. The second difference between the curves is that at the higher price, 80,000 tons of exports take place before any supply is placed in storage. Thus the marginal value of the export premium sales is higher than the marginal value of the first units of storage.

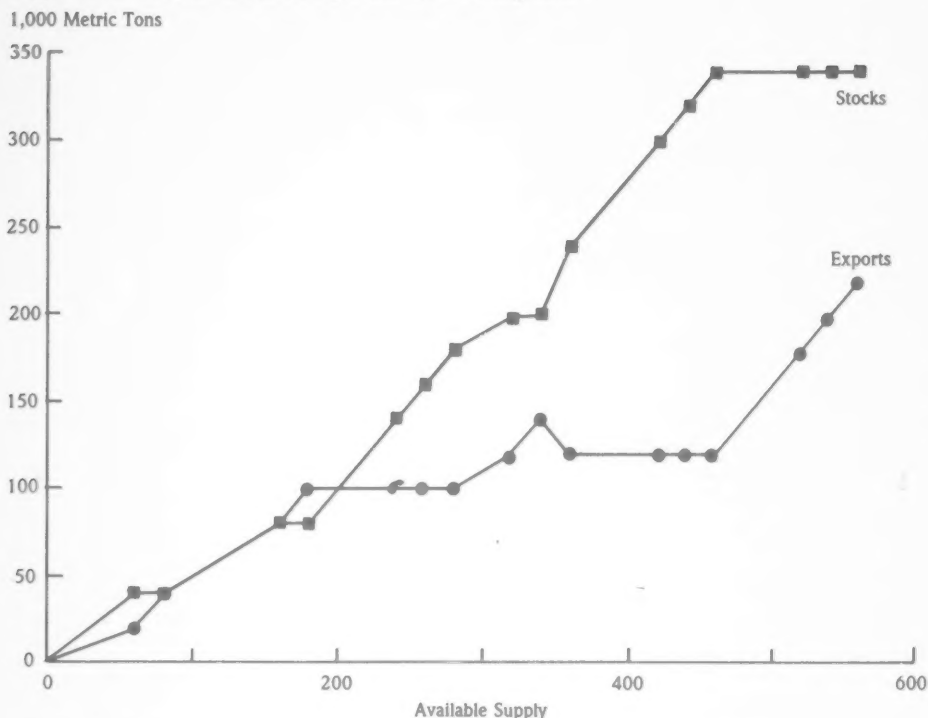
Both of these curves are in contrast to the price band curve, which simply places all supply into storage until the maximum stock is reached, and then exports the remainder. Two limitations of such a policy are clear: it ignores the presence of export premiums on small quantities of exports, and the maximum stock level is independent of world price.

Summary of Major Results

The major results from this chapter include the following:

1. The frequency distribution of price that results from a price band policy is quite different from the distribution under an optimal policy even when the standard deviation

Figure 13—Optimal closing stocks and exports



Note: Demand elasticity = -0.3 , production variability = 0.10 , and world price = US\$100.

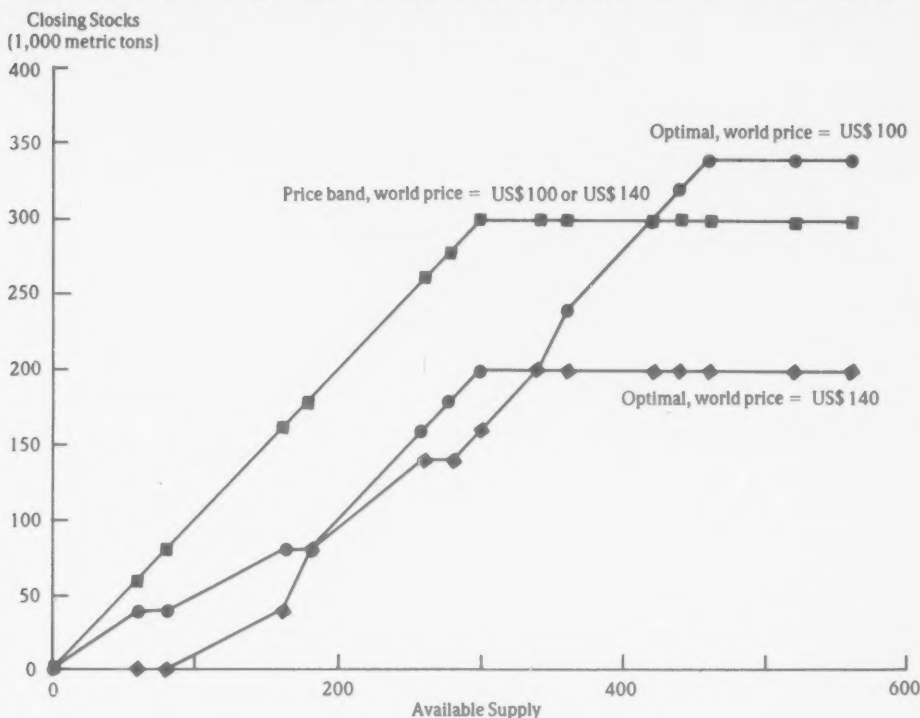
of price is held constant. For the price band policies, the distribution is strongly bimodal with a large majority of the prices at the extreme price limits. The optimal policies yield a relatively smooth distribution of prices.

2. The optimal policy net purchases (and thus domestic price) respond to world price and opening stock level, while net purchases for the price band schemes do not respond to those variables. By buying less (more) when world prices are high (low) and opening stock levels are high (low), the optimal policies save on fiscal cost.

3. The relationship between production and net purchases for the optimal policies is smooth, while it is kinked for the price band policies. The kinked relationship of the price band policies implies that the marginal cost of the next dollar price change at the limits is infinite; since this is not the case according to the objective function used here, the price band net purchases curve is inefficient.

4. The optimal export function is sensitive to world price in two ways: 100,000 tons of maize are exported before the maximum stock level is reached, and the maximum stock level itself is sensitive to the world price. The first 100,000-ton lot is exported to take advantage of the available export premiums. The maximum stock level adjusts, since the volume of future imports that can be bought with the cash gained from 1

Figure 14—Stocks: optimal versus price band policy at different world prices



Note: Demand elasticity = -0.3, production variability = 0.10.

ton of this year's exports increases with increasing world price. Thus the opportunity cost of holding stocks increases with higher world prices.

With these results in hand, the following chapter examines the trade-off between complexity of policy and cost. Based on the differences between the optimal and price band policies outlined above, changes are made in the price band policies to increase their efficiency. Chapter 7 presents policy recommendations and recommendations for policy analysts.

TRADE-OFFS BETWEEN GOVERNMENT OBJECTIVES

Trade-Offs Between Cost, Price Stability, and Imports

Figures 4 through 7 in Chapter 5 display the trade-off curves implied by the different policies. Since these can be slightly misleading for the purpose of measuring trade-offs, the results are presented numerically in Table 14. Trade-offs for price elasticity of -0.2 and production variability of 12 percent are presented in Appendix 1, Tables 21 and 22. As discussed above, buffer stocks are more effective at lower levels of price variability. The curves become steeper between corresponding levels of stock variability as price variability is decreased. This occurs because the slope of the line measures the relative effectiveness of only one instrument, increasing stock variability, which is subject to diminishing returns. With the optimal policies, on the other hand, all policy instruments can be adjusted simultaneously, and the least expensive adjustments are made. But with higher weights on price variability, the costs of making even minor adjustments in consumption are high, so the algorithm is constrained in the way it can adjust to a higher weight on imports. This leads to flatter curves for the low levels of price variability.

Such considerations can lead to the false conclusion that, for the price band schemes, the cost per unit decrease in imports declines with increasing price stability. This is not true, as Table 14 clearly shows, because as prices become more stable, higher

Table 14—Trade-offs between objectives: price band and optimal

Trade-off	Standard Deviation of Price			
	16.4	12.1	9.0	6.6
	(US\$1,000/year)			
Cost per 1,000-metric-ton decrease in average annual imports				
As imports decline from 48,000 to 40,000 metric tons				
Price bands	69	76	75	82
Optimal policies	27	52	75	81
As imports decline from 40,000 to 31,000 metric tons				
Price bands	121	136	166	202
Optimal policies	73	110	134	167
Cost per US\$ decrease in standard deviation of price				
With imports held constant at 48,000 metric tons				
Price bands	...	368	399	410
Optimal policies	...	335	417	501
With imports held constant at 31,000 metric tons				
Price bands	...	409	476	551
Optimal policies	...	451	540	630

levels of stock variability are required to maintain the same import level.³⁴ Although the line from 100,000 to 200,000 tons of stock variability is steeper with a smaller price band, the curve moving from imports of 40,000 to 31,000 is not.

The table confirms the impression of Figures 4 through 7 that for both the price band schemes and the optimal policies, price variability is the key determinant of cost. Each dollar decrease in price variability between \$9.00 and \$6.60 costs about \$500,000 annually for the optimal policies with imports held constant at 48,000 tons; the figure is \$630,000 when imports are held constant at 31,000 tons.

The cost of decreasing imports, while not as large in absolute terms as the cost of decreasing price variability, undergoes a larger percentage increase, rising from less than \$30,000 annually to almost \$170,000. The marginal cost increases as price stability increases, and also increases as imports decline.

With a few exceptions, the price band schemes overestimate the cost of decreasing imports. The price band estimates of the trade-off between lowering imports and lowering fiscal cost are particularly far off for high price variability. In this case, the optimal policies decrease imports by raising average prices. When the government preference for low imports is sufficiently high, this is preferred even though average prices are above the target price. On the other hand, with the width of the band held constant, the price band policies can reduce imports only by raising stock levels. This is very inefficient when prices are allowed to fluctuate widely.

In contrast to the fiscal cost/import trade-off, the trade-off between cost and price variability is almost always understated by the price band policies. The degree of underestimation increases as price variability declines. This appears to suggest that the price band schemes are more efficient at decreasing price variability than are the optimal policies.

But this is not the case. The optimal policies are the most efficient way to maximize the three objectives for any set of government preferences. Thus, the optimal policy measurements of the trade-offs are accurate. The reason for the relatively flat relationship between price variability and cost per unit of decrease in the price band schemes is that, as mentioned above, buffer stocks are more efficient policy instruments when prices are relatively stable. As price variability decreases, the price band curve gets closer to the optimal curve, biasing the measurement of the trade-off downward.

The Trade-Off Between Complexity and Cost

As shown above, the optimal policies achieve the government's objectives more efficiently than the price band policies. Despite these large differences in efficiency, several stockholding agencies in different parts of the world attempt to implement price band/buffer stock plans, while "in actual formulation of stockpiling strategy either at the national or at the international level . . . these [optimal stockpiling] models have barely been consulted" (Bigman and Yitzhaki 1983, 1). Cochrane (1980) suggests that risk considerations tend to make price band schemes with their floor and ceiling prices more intuitively appealing to both producers and consumers than the smooth intervention rules called for by optimal stockpiling analysis. Although the infinite marginal value attached to the next incremental price change in a price band scheme seems

³⁴ Trade-offs for demand elasticity of -0.2 and production variability of 12 percent are presented in Appendix 1, Tables 21 and 22.

irrational to an economist used to marginal analysis, the revealed preferences of governments around the world appear to be in favor of such schemes.

One compelling reason why optimal policies have never been implemented is the difficulty in communicating what they are. Indeed, the interpolated policies from the dynamic programming analysis are difficult to describe and implement. Savvy decision-makers who have seen complex cure-all projects disintegrate into chaos are likely to agree with Chambers' (1978) dictum that "simple is optimal" in policy design as well as in project selection, and to be wary of a policy that is difficult to describe, even for its proponents. Furthermore, the process of formulating public policy is so complex that policies that are difficult to communicate are unlikely to be accepted at the many decisionmaking levels necessary for successful implementation. There is thus an additional trade-off that needs to be examined here: the trade-off between the complexity of a policy and its efficiency. Apparently, the efficiency gains from optimal policies have not been sufficient to outweigh the costs involved in attempting to gain approval for and implement a complex policy.

Thus, if optimal stockpiling analysis is to have an effect on policy, it is likely to be through the clues it provides for modification of price band policies, or through the formulation of a relatively simple policy that is close to the optimal policy in most circumstances.

Possible modifications to the price band policies are suggested by the differences between the optimal and price band policies discussed in Chapter 5. Four differences have been identified: the maximum stock level in the optimal policies is dependent on the world price, with lower maximum levels prevailing at higher world prices; 100,000 tons of grain are exported before the maximum stock level is reached in order to take advantage of export premiums; net purchases of the stocking agency are sensitive to opening stocks and the world price; and net purchases are almost linearly related to production for constant opening stock level and world price. These four elements account for the large difference in efficiency between the two curves.

Learning from the Optimal Policy

One approach to the formulation of a relatively simple and efficient policy is to introduce the components of the optimal policy into the price band policy one by one, and measure the gain in efficiency at each step. For example, the first step could be to make the maximum stock level dependent on the world price. To accomplish this, however, it is necessary to know how sensitive the maximum stock level should be to the world price. Once estimates are made of the degree of sensitivity, the price band policies can be adjusted so that they respond to changes in the state variables to the same extent as the optimal policies.

The first step in the analysis is to choose the specific policy for consideration. The policy with a price weight of 17 and import weight of 60, which yields a standard deviation of price of \$12.10 and average imports of 44,700 tons, will be examined here.

Figures 10 through 12 suggest that the relationship between net purchases and the state variables (world price, opening stock level, and production) is close to linear. The following regression results confirm the suggestion:

$$NP_t = -1,826.8 + 0.5309 \cdot WP_t + 0.7847 \cdot Q_t - 0.09773 \cdot S_{t-1}; \quad (25)$$

(6.1) (0.0194) (0.0024) (0.0036)

$$N = 1,350, R^2 = 0.992, SEE = 15.98,$$

where

NP_t = net purchases,

WP_t = world price,

Q_t = production, and

S_{t-1} = opening stock level.

Standard errors are in parentheses. The regression includes all states in the model except for the extreme world prices of \$60 and \$180, for which the optimal results are not deemed accurate, since world prices cannot go below or above these extremes. Since each state of the world is not equally likely, the observations are weighted by the product of two factors: first, the probability of the production occurring, which is known in the model; second, a linear weighting scheme that decreases with increasing stocks. The second term is not exact, but reflects decreasing likelihood of higher stock levels occurring.³⁵

The second important relationship graphed in Chapter 5 is that between available supply and closing stocks (Figures 13 and 14). That relationship, however, appears to be piecewise linear in three segments and thus is not amenable to linear regression. The regression that can be run is maximum stock level on world price. Unfortunately, there are very few observations for this analysis, since the optimizing model considers only seven levels of world price and the two extreme values are somewhat suspect. With only five observations, the result is

$$MXST_t = 652 - 3.3 \cdot WP_t, \quad (26)$$

where $MXST_t$ is maximum stock level. This implies that when world prices are higher than \$198, nothing will be stored.

With these results in hand, the step-by-step analysis of the price band policies can begin. The easiest policies to implement are those that are more or less invisible to the populace if imports are held constant: making the maximum stock level sensitive to the world price and exporting small quantities frequently. These will be discussed in turn.

Surprisingly, the results are only slightly better for the price band with a flexible maximum stock level (policy A) than for the normal schemes. Table 15 lists the components of cost for policy A and the price band scheme with 250,000 tons of stock variability, which has the same level of average imports. Figure 15 displays the result for policy A as the point labeled "A".

As expected, export revenues increase substantially by lowering stock levels when world prices are high. Average export prices increase over 20 percent, but the increased stock level leads to lower export volumes, since imports and domestic trade are constant. The higher stock level leads to higher storage charges that are tempered somewhat by increased "earnings" from the replace stock account. Also on the negative side, average

³⁵ The unweighted equation is

$$-1,892.7 + 0.6007 \cdot WP_t + 0.8091 \cdot Q_t - 0.0760 \cdot S_{t-1},$$

with a slightly higher R^2 . A weighting scheme in which weights were chosen based on how often each state of the world occurs in the simulation was tried also. Results differ only marginally.

Table 15—Adjusting the price band policy

Policy	Import Volume	Average Annual Fiscal Cost	Average Stock Level	Replace Stock Charges	Storage Charges	Domestic Trading Losses	Foreign Trading Losses
	(1,000 metric tons)	(US\$ million)	(1,000 metric tons)			(US\$ million)	
Price band	30.0	3.35	126	-0.23	3.13	-0.92	1.36
Policy A	30.0	3.27	149	-0.43	3.47	-0.92	1.14
Optimal	30.0	1.45	103	-0.05	2.51	0.01	-1.02
(Policy A makes up 4 percent of the difference)							
Price band	41.7	1.95	49	0.44	1.33	-0.92	1.09
Policy B	41.7	1.37	60	0.35	1.66	-0.92	0.28
Optimal	41.7	0.34	60	0.35	1.48	-1.20	-0.29
(Policy B makes up 36 percent of the difference)							
Price band	42.8	1.86	44	0.48	1.21	-0.92	1.08
Policy C	42.8	1.02	56	0.37	1.62	-0.92	-0.05
Optimal	42.8	0.26	57	0.38	1.40	-1.30	-0.20
(Policy C makes up 53 percent of the difference)							
Price band	41.3	1.98	50	0.43	1.37	-0.92	1.09
Policy D	41.3	1.04	57	0.37	1.64	-0.59	-0.39
Optimal	41.3	0.37	61	0.34	1.51	-1.17	-0.32
(Policy D makes up 58 percent of the difference)							
Price band	41.5	1.97	49	0.44	1.36	0.92	1.09
Policy F	41.5	0.48	54	0.40	1.54	-1.25	-0.21
Optimal	41.5	0.35	60	0.35	1.50	-1.18	-0.30
(Policy F makes up 92 percent of the difference)							

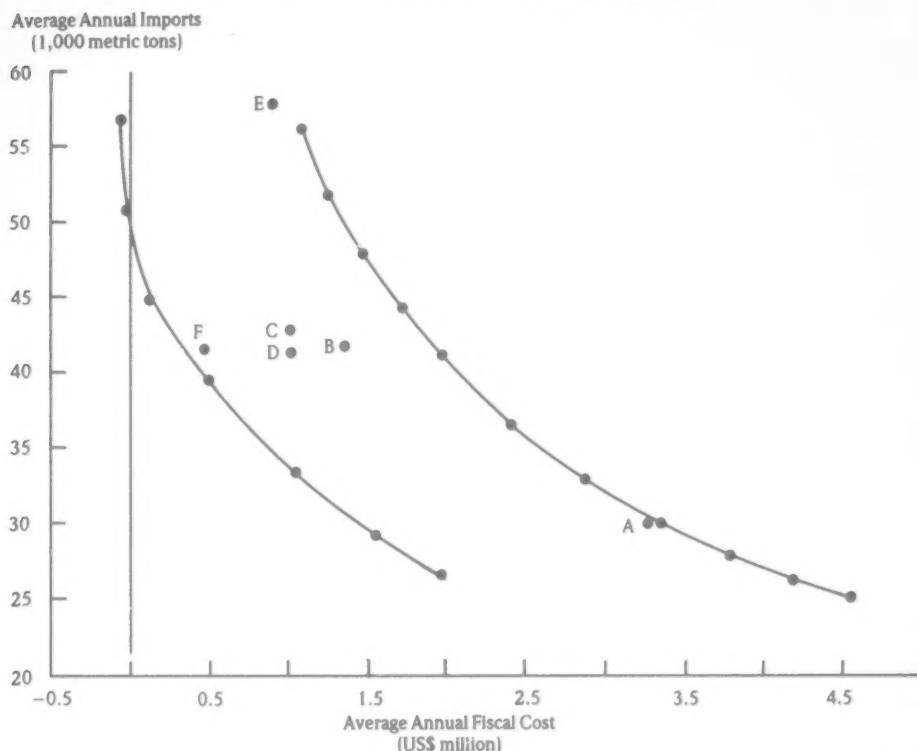
Notes: Policy A is a price band policy modified by the introduction of a flexible maximum stock level. Policy B is policy A modified by allowing half of the first 200,000 metric tons of available supply to be exported. Policy C is policy B modified by making net purchases sensitive to the world price. Policy D is policy C modified by making net purchases sensitive to opening stocks. Policy F is policy B modified by replacing the price band rule with a piecewise linear net purchases function.

import prices increase; this results from more of the imports taking place when world prices are high, since the maximum stock level is lower when world prices are high. The net result of these different factors is a gain of only about \$80,000 annually. As the optimal policy achieves the same level of imports for \$1.9 million less annually, this adjustment has made up only about 4 percent of the difference.

The next step on the exporting side is to allow the model to take advantage of the export premium that prevails when exports are small. The optimal policies examined in Chapter 5 suggest that a convenient rule of thumb might be to export one-half of the first 200,000 tons of available supply, then put the remainder in store until the maximum stock level is reached. This adjustment has a large payoff, as is evident in Table 15 and Figure 15 (the relevant point is labeled "B" in the figure).

This policy moves much closer to the optimal results, although a significant difference remains. The comparison with policy A is obscured somewhat by the large difference in import volumes, but one major change is that the additional exports in years

Figure 15—Moving toward the optimal: price band policy modifications



Notes: Policy A is a price band policy modified by the introduction of a flexible maximum stock level. Policy B is policy A modified by allowing half of the first 200,000 metric tons of available supply to be exported. Policy C is policy B modified by making net purchases sensitive to the world price. Policy D is policy C modified by making net purchases sensitive to opening stocks. Policy E is Policy D modified by making net purchases sensitive to production. Policy F is policy B modified by replacing the price band rule with a piecewise linear net purchases function.

of relatively low available supply keep export volumes from falling relative to the price band policy, as they did under policy A. Despite the gains made on the foreign trade side, however, a large difference remains between the foreign trade losses under policy B and the profits from trade under the optimal policies. Making the domestic market price sensitive to the world price is one way to close the gap.

Policy C attempts to accomplish that task. The domestic market continues to have a floor and ceiling price with a constant difference between them, but both maximum and minimum trigger prices move somewhat with world prices. This is accomplished in the model by taking the world price coefficient from the net purchases regression estimated above, multiplying it by the deviation of world price from \$120.00 (the base world price), and adding the result to the production volume triggers ($Q_{\min}$ and $Q_{\max}$ as defined in equations (20) and (21) of Chapter 4). The resulting change in the price triggers is not particularly large; in policy C when world prices are at their base of

\$120.00, the lower price trigger is \$128.10, while the corresponding trigger for a world price of \$100.00 is \$126.20.³⁶

Even these small changes, however, have significant results, with policy C more than 50 percent of the way from the price band scheme to the optimal policy. The major difference between policies B and C is in the price of imports and exports. Since lower volumes are sold domestically when world prices are high and domestic production is low, fewer imports are needed in those years, while relatively more is imported when world prices are low. A similar story can be told for the domestic purchases/export side. Thus, average import prices are about 5 percent lower and average export prices about 4 percent higher under policy C than under policy B.

Despite these gains, the optimal policy remains \$750,000 dollars cheaper on average. This results from a combination of higher domestic profits, lower storage charges, and a continued lead in foreign trade despite the substantial gains made. The last remaining way to make the policy more similar to the optimal policy while retaining maximum and minimum prices is to allow the triggers to vary with opening stock.

Policy D, then, makes this change. This is accomplished by multiplying the coefficient from the estimated regression by the deviation of the stock level from 100,000 tons, and adding the result to the volume triggers computed by policy C ($Q_{\min}$ and $Q_{\max}$). As in the case of the world price adjustment, the changes in price are not large; an increase in the stock level from 100,000 to 200,000 tons increases the lower trigger from \$128.10 to \$129.90. Nevertheless, the results are significant if not dramatic, as shown in Table 15 and Figure 15.

Policy D is almost 60 percent of the way from the price band policy to the optimal policy. The change from policy C to D is somewhat different from the expected, however. Considerably lower profits are made domestically under policy D, while the cost of imports drops. The policy has adjusted by increasing domestic purchases when stocks are less than 100,000 tons. Since the greater number of years fall in this range, net domestic purchases have increased, displacing imports and raising the average domestic price slightly. Since domestic maize is cheaper on average than imported maize, this has resulted in some efficiency gains.³⁷

Policy D is virtually identical to the optimal policy in the foreign trade account; the remaining differences between the policies are primarily in the domestic account. The next step in trying to approximate the optimal policy is to forgo the idea of minimum and maximum prices altogether. All elements of the regression estimated above have been entered into policy D except the smooth relation between net purchases and production. This is added in policy E.

The result is surprising, as the policy has a cost of \$920,000 and average imports of 57,700 tons.³⁸ As Figure 15 indicates, policy E is only marginally superior to the

³⁶ Policies C and D must have a smaller maximum percentage deviation of price in order to achieve the same standard deviation of price. The standard price band scheme requires a percent limit of 9.37 percent to achieve a standard deviation of price of \$12.10; the percent limit for C is 8.86 percent, while the limit for D is 8.84 percent. The percent variability allowed must be adjusted because of the price flexibility that is added by the sensitivity of the triggers to opening stocks and world price.

³⁷ Policy D was also run using 80,000 rather than 100,000 tons in the computation of the trigger adjustment. The result was inferior to the one presented.

³⁸ The standard deviation of price that results from simulating the net purchases equation estimated above is \$13.00. In order to lower the price variability to \$21.10, an equation was estimated for an optimal policy with a lower price variability, and the coefficients were interpolated to yield the net purchases equation used for policy E. The interpolated equation is

$$NP_t = -1,855 + 0.49 \cdot WP_t + 0.80 \cdot Q_t - 0.091 \cdot S_t - 1.$$

price band policy. Despite the very high R^2 of the net purchases equation, the standard error of the estimate (16,000 tons) is large enough to cause the policy to be quite inefficient.

Figures 11 through 13 suggest that a more appropriate way to model the optimal net purchases function would be to use three linear segments: first, for production greater than or equal to normal; second, for production less than normal but with the shortfall less than the opening stock level; and third, for production plus opening stocks less than normal production. The following regressions, estimated from the standard optimal policy with price weight of 17 and import weight of 60, indicate that this is a fruitful way to proceed:

$$Q_t \geq 2250, \quad (27)$$

$$NP_t = -1,937.3 + 0.6121 \cdot WP_t + 0.8219 \cdot Q_t - 0.05317 \cdot S_{t-1};$$

(7.4) (0.0150) (0.0030) (0.0028)

$$N = 750, R^2 = 0.994, SEE = 9.44.$$

$$Q_t < 2250 \text{ and } Q_t + S_{t-1} \geq 2250, \quad (28)$$

$$NP_t = -1,916.7 + 0.5098 \cdot WP_t + 0.8201 \cdot Q_t - 0.07441 \cdot S_{t-1};$$

(16.3) (0.0194) (0.0074) (0.0047)

$$N = 280, R^2 = 0.990, SEE = 7.25.$$

$$Q_t + S_{t-1} < 2250, \quad (29)$$

$$NP_t = -1,925.6 + 0.3207 \cdot WP_t + 0.8550 \cdot Q_t - 0.08770 \cdot S_{t-1};$$

(17.8) (0.0345) (0.0084) (0.0118)

$$N = 320, R^2 = 0.989, SEE = 12.92.$$

Standard errors are in parentheses.

All of the coefficients are significantly different from the corresponding coefficients in the other two equations except the coefficients of production in equations (27) and (28). More important for the purposes at hand, all of the standard errors are considerably less than the standard error of 15.98 for the original equation (25). The standard error of 7.25 for equation (28) is about as small as could be expected when the original data are constrained to multiples of 20.

The results of simulating a policy with net purchases defined by a piecewise linear function are exceptionally close to the optimal policy, as shown in Table 15 and Figure 15.³⁰ The primary difference between policy D and the optimal policy is on the export

³⁰ As in the case of the linear net purchases equation, the standard deviation of price is higher than \$12.10 when the equations given in the text are simulated. Consequently, the same equations were estimated for an optimal policy with a lower level of price variability and the coefficients interpolated to yield the following three equations, which produce the results in Table 15:

$$\begin{aligned} Q_t > 2,250: & -1,954.7 + 0.5796 \cdot WP_t + 0.8317 \cdot Q_t - 0.0506 \cdot S_{t-1}, \\ 2,250 - S_{t-1} < Q_t < 2,250: & -1,932.0 + 0.4844 \cdot WP_t + 0.8287 \cdot Q_t - 0.0714 \cdot S_{t-1}, \\ Q_t < 2,250 - S_{t-1}: & -1,940.3 + 0.3095 \cdot WP_t + 0.8618 \cdot Q_t - 0.0824 \cdot S_{t-1}. \end{aligned}$$

side. This is most likely the result of always exporting 100,000 of the first 200,000 tons of available supply; Figures 13 and 14 indicate that the slope and placement of that first segment are somewhat sensitive to world price, as would be anticipated. Nevertheless, the modeled policy is very close. Since the standard deviation of cost is almost \$3 million, policy F would be indistinguishable from the optimal policy in practice.

Summary of Major Results

The price band schemes generally underestimate the cost of decreasing price variability, since these schemes become relatively more efficient with decreasing price variability.

The cost of decreasing annual average imports by 1,000 tons ranges from \$27,000 to almost \$170,000 annually; the cost increases with decreases in price variability and average imports. The higher the weight on price variability, the less flexibility is allowed the optimizing algorithm in adjusting consumption to match production. Thus as price variability declines, the optimal policies are forced to hold more stocks in order to decrease imports, rather than allowing consumption to fall when production is low. This leads to a higher trade-off between imports and cost.

The cost of decreasing the standard deviation of price by \$1.00 per ton ranges from \$330,000 to \$630,000 annually. This cost also increases with decreases in price variability and average imports.

It is possible to make up about 60 percent of the difference between the price band and optimal policies while retaining the maximum and minimum triggers of a price band scheme. The larger share of the remaining difference can be made up by making net purchases a piecewise linear function of production, world price, and opening stocks.

CONCLUSIONS AND POLICY IMPLICATIONS

At this point, the trade-offs between different government objectives have been measured, and the optimal policies have been compared and contrasted with the price band policies. The previous chapters show that there is considerable room for improvement upon the simple price band policies considered earlier by the Inter-Ministerial Working Group and that a relatively simple policy is virtually as efficient as the optimal policy. This chapter examines the implications, first, for policy analysis in general, and second, for policymakers in Kenya.

Implications for Policy Analysis

Four benefits of optimization are outlined in Chapter 3: the screening of many policy alternatives, the accurate measurement of trade-offs between objectives, the measurement of the degree of suboptimality of alternative policies, and the opportunity to learn from the optimal policy. The major methodological question addressed by this study is whether or not these benefits of optimization outweigh the considerable costs of the optimization process. Given the nature of the results, the answer is undoubtedly yes. The major objective of the study was to measure trade-offs; as shown in Chapter 6, the simulated price band policies do not measure accurately the trade-off between cost and price stability, or between cost and imports. So for that reason alone, the optimization process has been necessary and worthwhile.

The gains from optimization were not limited to the measurement of trade-offs, however. The optimization process screened out the infinitely many possible shapes of the net purchases function and suggested its formulation as a piecewise linear curve with three segments. The degree of suboptimality of the price band policies was seen to be large, and therefore these policies were modified based on insights provided by the optimal policy. Since policy F—the policy with a piecewise net purchases function, flexible maximum stock level, and exports of 100,000 tons of the first 200,000 tons of available supply—was only slightly suboptimal, no further modifications were made. Without having the goal of the optimal trade-off curve in mind, there would have been no way of knowing whether or not policies that are far superior to policy F exist.

The optimal policies themselves challenge some of the common assumptions about maize policy in Kenya. For example, most economists, including the author of this study, thought that carry-out stocks in 1982 and 1983 were too high and the government should have exported in those years. If the minimum stock level kept on hand as a cushion for the arrangement of imports is considered to be 300,000 tons, then carry-out (used in the sense of this study, total stock minus the import cushion) during 1982 and 1983 was about 350,000 tons. The model shows that these amounts were not excessive given some reasonable combinations of objective function weights and 1982/83 world prices and production levels, particularly with the 12 percent production variability assumption.

Thus optimization yields many insights into the problem and possible solutions, and was undoubtedly a profitable way to proceed given the objectives and constraints of the study. But this analysis was conducted in a research environment. The situation

of a Third World government economist who needs to complete a report within a month if it is to affect the decisionmaking process is quite different; optimization may be impossible in such circumstances. The following lessons are proposed.

If the structure of the model used here is fairly similar to the structure of the market in the country of interest, it would be possible to accept a policy like policy F as a proxy for an optimal policy and simulate that policy across a large number of different parameters to approximate an optimal outcome. Trade-offs could be measured by this curve, and other policies compared to it for sub-"optimality".

On the other hand, there could be circumstances in which the basic structure of the policy has already been decided. In such circumstances, optimization may not be necessary. For example, if the price band policy studied by the Inter-Ministerial Working Group had been accepted as a strategy, the trade-offs measured by the price band curves would have been the relevant numbers for the government. Because there are only two parameters to vary with these policies, it is quite easy to find the best policy of this type without optimization. More complex policies that require several parameters for a complete definition will be less amenable to finding the best choice through simulation. For sufficiently complex policies, some optimization, perhaps of a subset of the problem, may be necessary.

Optimization was useful to this study even though the specific policies that were produced by the optimization process are not recommended. This point has been made elsewhere: "Formal and simplified optimization can provide a number of useful starting points for a process of policy design and dialogue. In no sense does it guarantee an optimal or even adequate policy" (Clark, Jones, and Holling 1979, 32). Utility functions of decisionmakers are always more complex than those that become the objective functions of optimization models; in addition, the process of reforming public policy always involves a set of compromises among officials with different utility functions. No optimization model can possibly deal completely with such complex situations. Nevertheless, as an aid to policy design, as a screening method across policy alternatives, as a reference point for other policies, and as a measuring device for trade-offs, the dynamic programming analysis has been invaluable.

Implications for Policy

For Kenyan decisionmakers, the key results that come out of this study are the high savings associated with increased price flexibility. At the lowest end of price stability measured here, each dollar increase in the standard deviation of price saves \$400,000-\$600,000 annually. This implies that a policy that has a standard deviation of price of 5 percent of the target price would be at least \$3.5 million and probably closer to \$6 million less in annual average cost than a policy that succeeded in holding prices constant.⁴⁰ These figures represent between one-tenth and one-fifth of the annual development budget of Kenya's Ministry of Agriculture. Given these high costs, it is not surprising that the NCPB has failed to implement the stated policy of keeping prices constant.

As demonstrated in Chapter 2, under present policies there is de facto price flexibility. This is the result of the large costs associated with implementing the stated

⁴⁰ Since the cost per unit decrease in price variability would continue to increase as price variability decreased, the numbers given in the text for average annual cost are slightly higher than the trade-offs found in the table.

policy of constant prices. If this existing price instability were acknowledged and built into the system, the price instability could be spread out over a larger population, causing less stress on any one group. In addition, an explicit decision could be made by senior officials about the trade-off between cost and price stability rather than forcing parastatal officials to make the decision based on their own fiscal constraints.

Both policy D and policy F described in Chapter 6 appear to be large improvements over the present policy and the type of price band schemes previously analyzed. The main elements of these policies are flexibility to world price, opening stocks, and production. Both policies make closing stocks sensitive to world price, and allow some exports if a white maize premium is available. In addition, both policies allow domestic net purchases—and thus the domestic price—to vary with the world price and opening stocks of the marketing board. The main difference between the two policies is that policy F allows the domestic price to vary somewhat with domestic production.⁴¹

This final adjustment saves a large amount of money, but would require more radical adjustments to present policy. Questions about implementation of these types of policies are addressed in the following section.

Considerations for Implementation

Implementation issues will be considered, first, for the foreign trade/domestic stock rules, which are the same for policies D and F; second, for a domestic price policy that is flexible with respect to opening stocks and world prices; and finally, for a domestic price policy that adjusts for unanticipated changes in domestic production.

Foreign Trade and Domestic Storage Policy

The export rules considered above—varying the maximum stock level inversely with the world price, and exporting one-half of the reserve stock if significant white maize premiums are available—would be easy to implement. The results in Chapter 5 clearly show that this type of export rule dominates rules in which exports are triggered by stocks alone. Since the policy can be set up so that on average the same amount of maize is imported as under any particular storage trigger policy, this aspect of the policy modification can be made invisible on average to consumers and producers.

The maximum stock level, however, should also be dependent on the government's relative preferences for low imports, low price variability, and low fiscal costs. If the government's desire to minimize imports were to decline, the correct maximum stock level would decline also. The relationship between maximum stock level and world price that was estimated in Chapter 6 was appropriate for a policy that allows price to vary plus or minus about 9 percent from the target price (price variability of \$12.10) and that yields average imports of about 45,000 tons. A somewhat different relationship would hold with smaller or larger price bands, or with a different preference for imports. These different relationships could be estimated from the appropriate optimal policy.

⁴¹ The implied elasticity of domestic price for domestic production in policy F is about -0.6, implying that a 20 percent shortfall in production would lead to a 12 percent increase in the official price. This elasticity, however, is a function of the government's assumed preference for price stability. The elasticity would be lower if the preference for price stability were assumed to be higher.

Price Policy Responsive to Opening Stocks and World Price

At present, official producer prices for the harvest are announced before planting time, and official consumer prices are announced for the next 12 months about 1 month before the first maize is harvested. Clearly, any move toward flexible official prices would change this procedure considerably.

The type of modifications discussed here, however, could be implemented with relatively minor modifications to the present policy. It is shown in Chapter 5 that the degree to which domestic prices respond to world price and opening stocks in policy D is not large. Thus it would be possible to announce a floor price at planting time based on an optimistic prediction about end-year stocks and a pessimistic prediction of the world price at harvest time. These predictions should be sufficiently optimistic/pessimistic so that it is unlikely that actual stocks and world prices would be respectively higher or lower than the predicted value. Thus the announced floor price would be the lowest possible optimal domestic price.

At the time of announcement, the public could be informed that the government buying price is expected to be higher than the floor price. The government might find it in its interest to announce an expected price or a maximum price or both simultaneously with the floor price. The announcement could include indications of how sensitive the price would be to changes in the world price and government stocks. The expected buying price—based on the expected values of the two key variables—could be published in the local press regularly. A similar procedure could be followed for the government selling price.

Before the buying season begins, the government would make a final announcement; all maize bought during that marketing year would be at the set price. During the year, farmers would have the option of selling to the NCPB at the floor price or selling to traders; millers would have the option of buying from the board at the government selling price or buying directly from farmers or traders.

For the farmer the most significant change resulting from such a policy would be the possibility of adjustments in official prices after the crop has been planted. But given the fairly small sensitivity of domestic price to world price and opening stocks measured in the previous chapters, the required adjustments would not be large. There would have to be large, unanticipated movements in world prices and domestic stocks for the required price change to be as large as 10 percent. The possibility of such a price change is much less than many farmers experience under the present system with the possibility of waiting many months to receive payment, or not being able to sell to the board at all.

For the urban consumer, the presence of a price band would imply that there would be some change in price during the year, with lower prices at harvest time and higher prices before harvest in most years.⁴² The extent of these changes would be determined by the width of the price band.

Price Policy Responsive to Domestic Production

The domestic price could be made sensitive to domestic production in a similar fashion. Theoretically, the policy adjustment is simple: before planting time, calculate

⁴² The price rise would result not from changes in official prices, but from storage costs incurred by the private sector. Such price rises would occur only in years during which the price is between the NCPB floor and ceiling during some months. There would be no seasonal price rise during a poor crop year in which the NCPB's ceiling price was effective at harvest time and remained effective throughout the year.

the floor price after taking into account an optimistic estimate of production. The final price would be determined by the actual production level.

Production estimates, however, are subjective, unreliable (as discussed in Chapter 4), and unavailable until after most of the crop has been purchased. In addition, the buying season in Kenya is spread out over about six months, with purchases in the west beginning long before the large purchases from the Rift Valley. A price policy that depends on subjective estimates of production several months before the major harvest would be subject to large errors. Given these problems, implementation of a policy such as this one probably could be done most efficiently by a series of tender offers.⁴³

A tender procedure for implementing such a policy might look like the following. Suppose it is August. The harvest is beginning in the west, and total annual production is predicted to be about 200,000 tons above trend. Given this production estimate and the present stock level and world price, suppose that the chosen strategy calls for a price of \$125 per ton and net purchases of 100,000 tons for the year. The NCPB could advertise a tender offer to buy, say, a total of 10,000 tons for delivery in September in appropriately sized lots, and ask for bids. The bidding process would give the board additional feedback on prices and production, and this information would be used when deciding how much to offer to buy in October. Similar offers could be made in each of the months of the buying season.

Such a procedure may be workable, but the mechanism would be considerably more complicated and management-intensive than setting floor and ceiling prices. The cost savings that result from making the domestic price sensitive to production are about \$600,000 in average annual cost. Whether or not the benefits of cost savings outweigh the increased complexity of implementation and administration is a political judgment.

Conclusions

This study has measured trade-offs between government objectives and has given indications of how the efficient policies that result from the model might be implemented. The three major trade-offs are between cost and price stability, between cost and imports, and between cost and complexity. The next step in policy reform is political; deciding how important each of the goals—price stability, low imports, low fiscal cost, low complexity of policy—is relative to the others.

A general strategy for pricing, stockholding, and foreign trading would be determined through the political choice of a strategy that yields a feasible combination of the objectives. Before the strategy is implemented, however, it would be desirable to study the tactical decisions of how the policy would be implemented within the seasonal and regional framework of the real world. For deciding on the broad approach the country wishes to pursue, a model that includes regions of the country and seasons of the year would have obscured rather than clarified the issues. For choosing the exact specification of the policy once a broad approach has been decided upon, however, a quarterly or monthly management model that includes four or five regions could be quite helpful. The purpose of the management model would be to determine the best way to achieve the annual values of the variables recommended by the accepted strategy. Thus, the model would only need to be 12 or 18 months long. Although the paucity of data would mean that heroic assumptions would have to be made about some of

⁴³ An alternative might be to base the decision on an objective measure, such as rainfall at particular stations.

the parameters, considerable insight could be gained into the best methods for implementing the chosen policy in the real world.

The study, then, has outlined the economic costs and benefits of some major choices available to the Kenyan government and has sketched the analytical steps that follow from acceptance of a specific strategy. Much can be gained in terms of lower cost and lower imports by allowing prices to reflect domestic production, world price, and domestic stock levels. The types of policies outlined here would be considerably more efficient at increasing price flexibility than the simple price band/buffer stock policy that was simulated by the Inter-Ministerial Working Group.

APPENDIX 1: SUPPLEMENTARY TABLES

Table 16—Price band results for demand elasticity equal -0.2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	Components of Fiscal Cost			
							(8)	(9)	(10)	(11)
Price Band	Stock Variability	Standard Deviation of Price	Imports	Average Annual Fiscal Cost	Standard Deviation of Cost	Average Stock Level	Replace Stock Charges	Storage Costs	Domestic Trading Losses	Foreign Trading Losses
(percent)	(1,000 metric tons)	(US\$/metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)		(US\$ million)		
4.75	0	6.5	72.5	3.41	3.35	0	0.86	0.00	-0.08	2.62
4.75	100	6.5	54.5	3.90	3.49	51	0.43	1.36	-0.08	2.21
4.75	200	6.5	43.6	4.60	3.78	103	-0.03	2.59	-0.08	2.12
4.75	300	6.5	37.1	5.47	4.24	153	-0.47	3.71	-0.08	2.29
4.75	400	6.5	33.1	6.28	4.76	201	-0.88	4.67	-0.08	2.58
6.75	0	9.1	68.7	2.65	3.25	0	0.86	0.00	-0.48	2.26
6.75	100	9.1	51.4	3.23	3.39	51	0.43	1.37	-0.48	1.92
6.75	200	9.1	41.0	3.98	3.71	103	-0.03	2.59	-0.48	1.89
6.75	300	9.1	34.9	4.87	4.18	153	-0.45	3.71	-0.48	2.09
6.75	400	9.1	31.2	5.70	4.72	200	-0.86	4.63	-0.48	2.41
9.20	0	12.2	64.3	1.78	3.13	0	0.86	0.00	-0.92	1.84
9.20	100	12.2	47.7	2.47	3.30	51	0.43	1.38	-0.92	1.60
9.20	200	12.2	38.0	3.27	3.65	103	-0.03	2.59	-0.92	1.62
9.20	300	12.2	32.3	4.18	4.14	152	-0.45	3.69	-0.92	1.86
9.20	400	12.2	29.0	5.00	4.68	199	-0.86	4.58	-0.92	2.21
13.10	0	17.0	57.8	0.57	2.94	0	0.86	0.00	-1.54	1.25
13.10	100	17.0	42.3	1.44	3.17	51	0.43	1.40	-1.54	1.16
13.10	200	17.0	33.7	2.30	3.55	102	-0.01	2.59	-1.54	1.26
13.10	300	17.0	28.7	3.21	4.09	151	-0.44	3.63	-1.54	1.57
13.10	400	17.0	25.9	4.02	4.66	197	-0.84	4.47	-1.54	1.93

Table 17—Price band results for production variability equal 12 percent

(1)	(2)	(3)	(4)	(5)	(6)	(7)	Components of Fiscal Cost			
							(8)	(9)	(10)	(11)
Price Band	Stock Variability	Standard Deviation of Price	Imports	Average Annual Fiscal Cost	Standard Deviation of Cost	Average Stock Level	Replace Stock Charges	Storage Costs	Domestic Trading Losses	Foreign Trading Losses
(percent)	(1,000 metric tons)	(US\$/metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)			(US\$ million)	
5.10	0	6.9	84.0	3.71	4.05	0	0.86	0.00	-0.23	3.06
5.10	100	6.9	66.0	4.23	4.16	51	0.43	1.36	-0.23	2.67
5.10	200	6.9	54.3	4.91	4.46	103	-0.03	2.58	-0.23	2.57
5.10	300	6.9	46.7	5.72	4.86	153	-0.47	3.74	-0.23	2.67
5.10	400	6.9	41.8	6.56	5.36	202	-0.89	4.75	-0.23	2.93
5.10	450	6.9	40.1	6.95	5.62	226	-1.09	5.19	-0.23	3.07
5.10	500	6.9	38.8	7.33	5.88	249	-1.29	5.60	-0.23	3.25
6.80	0	9.1	79.5	2.86	3.90	0	0.86	0.00	-0.67	2.65
6.80	100	9.1	62.1	3.47	4.06	51	0.43	1.36	-0.67	2.36
6.80	200	9.1	51.0	4.20	4.36	103	-0.03	2.58	-0.67	2.30
6.80	300	9.1	44.0	5.04	4.79	152	-0.45	3.71	-0.67	2.45
6.80	400	9.1	39.5	5.87	5.30	201	-0.88	4.70	-0.67	2.73
9.55	0	12.5	72.4	1.62	3.71	0	0.86	0.00	-1.24	2.00
9.55	100	12.5	56.1	2.41	3.90	51	0.43	1.37	-1.24	1.84
9.55	200	12.5	46.0	3.19	4.24	102	-0.03	2.58	-1.24	1.36
9.55	300	12.5	39.7	4.07	4.70	151	-0.45	3.69	-1.24	2.08
9.55	400	12.5	35.7	4.90	5.23	199	-0.86	4.60	-1.24	2.38
12.82	0	16.4	64.7	0.36	3.50	0	0.86	0.00	-1.80	1.28
12.82	100	16.4	49.6	1.30	3.75	51	0.43	1.40	-1.80	1.28
12.82	200	16.4	40.6	2.17	4.14	101	-0.01	2.57	-1.80	1.40
12.82	300	16.4	35.1	3.09	4.64	150	-0.44	3.63	-1.80	1.68
12.82	400	16.4	31.7	3.90	5.19	196	-0.84	4.51	-1.80	2.02

Table 18—Optimal policy results for demand elasticity equal -0.2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	Components of Fiscal Cost			
							(8)	(9)	(10)	(11)
Price Stability Weight	Import Weight	Standard Deviation of Price	Imports	Average Annual Fiscal Cost	Standard Deviation of Cost	Average Stock Level	Replace Stock Charges	Storage Costs	Domestic Trading Losses	Foreign Trading Losses
		(US\$/ metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)		(US\$ million)		
33.0	92	6.5	49.6	3.14	3.58	94	0.05	2.20	-0.32	1.21
35.9	138	6.5	43.5	3.73	3.90	121	-0.18	2.89	-0.03	1.05
39.4	184	6.5	39.1	4.28	4.15	146	-0.40	3.42	0.18	1.08
43.1	230	6.5	36.0	4.78	4.36	170	-0.60	3.85	0.40	1.13
47.2	276	6.5	33.6	5.31	4.68	188	-0.76	4.29	0.55	1.23
21.7	69	9.1	50.5	2.07	3.21	74	0.23	1.74	-0.86	0.96
22.8	115	9.1	43.7	2.57	3.54	103	-0.03	2.45	-0.61	0.76
24.9	161	9.1	38.2	3.21	3.89	129	-0.25	3.10	-0.36	0.72
27.1	207	9.1	35.7	3.59	4.12	146	-0.40	3.43	-0.12	0.68
29.3	253	9.1	32.6	4.14	4.34	170	-0.61	3.89	0.20	0.67
14.1	46	12.2	52.7	0.84	2.79	52	0.42	1.28	-1.77	0.91
15.6	92	12.2	45.4	1.24	3.14	78	0.19	1.86	-1.28	0.45
16.9	138	12.2	39.0	1.80	3.47	104	-0.04	2.48	-0.84	0.19
18.2	184	12.2	34.3	2.41	3.82	129	-0.25	3.08	-0.56	0.15
19.6	230	12.2	31.1	2.95	4.07	149	-0.43	3.50	-0.25	0.13
8.8	33	17.0	51.4	-0.64	2.41	39	0.53	0.96	-2.94	0.81
9.8	79	17.0	42.8	-0.24	2.82	61	0.33	1.51	-2.08	-0.02
10.7	126	17.0	36.9	0.25	3.11	86	0.12	2.06	-1.58	-0.35
11.8	172	17.0	31.8	0.86	3.46	110	-0.08	2.61	-1.07	-0.58
12.6	219	17.0	28.6	1.37	3.76	128	-0.24	3.04	-0.77	-0.65

Table 19—Optimal policy results for production instability equal 12 percent

(1)	(2)	(3)	(4)	(5)	(6)	(7)	Components of Fiscal Cost			
							(8)	(9)	(10)	(11)
Price Stability Weight	Import Weight	Standard Deviation of Price	Imports	Average Annual Fiscal Cost	Standard Deviation of Cost	Average Stock Level	Replace Stock Charges	Storage Costs	Domestic Trading Losses	Foreign Trading Losses
		(US\$/ metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)		(US\$ million)		
42.5	99	6.9	57.3	3.34	4.26	106	-0.05	2.46	-0.31	1.24
47.2	146	6.9	51.0	3.90	4.62	133	-0.29	3.10	0.05	1.04
52.3	193	6.9	45.8	4.54	4.94	158	-0.50	3.70	0.41	0.93
56.9	240	6.9	42.5	5.04	5.19	180	-0.69	4.14	0.73	0.88
62.0	287	6.9	39.5	5.68	5.42	200	-0.86	4.62	1.00	0.93
30.2	92	9.1	56.0	2.24	4.01	92	0.07	2.18	-0.74	0.73
33.2	138	9.1	48.8	2.87	4.35	123	-0.20	2.87	-0.32	0.51
36.5	184	9.1	43.6	3.49	4.68	145	-0.40	3.43	0.07	0.37
40.0	230	9.1	40.3	4.01	4.98	164	-0.55	3.85	0.49	0.23
43.6	276	9.1	37.3	4.52	5.23	182	-0.71	4.26	0.80	0.17
18.9	69	12.5	55.2	0.63	3.47	72	0.24	1.72	-1.93	0.59
21.4	115	12.5	48.5	1.10	3.83	92	0.07	2.22	-1.20	0.00
23.9	161	12.5	42.6	1.71	4.21	119	0.07	2.77	-0.48	-0.41
25.8	207	12.5	38.2	2.28	4.54	139	-0.34	3.27	-0.02	-0.62
28.2	253	12.5	34.8	2.82	4.84	156	-0.48	3.67	0.42	-0.80
12.0	40	16.4	56.8	-1.09	2.82	45	0.48	1.13	-3.37	0.67
13.4	80	16.4	49.5	-0.77	3.23	63	0.32	1.53	-2.44	-0.19
15.1	120	16.4	43.7	-0.37	3.62	80	0.17	1.94	-1.60	-0.87
16.5	160	16.4	38.9	0.16	3.91	100	0.00	2.37	-0.96	-1.25
17.8	200	16.4	34.4	0.71	4.17	116	-0.14	2.80	-0.51	-1.43

Table 20—Price band results for comparison with optimal

(1) Price Band	(2) Stock Vari- ability	(3) Standard Deviation of Price	(4) Imports	(5) Average Annual Fiscal Cost	(6) Standard Deviation of Cost	(7) Average Stock Level	Components of Fiscal Cost			
							(8)	(9)	(10)	(11)
							Replace Stock Charges	Storage Costs	Domestic Trading Losses	Foreign Trading Losses
(percent)	(1,000 metric tons)	(US\$/ metric ton)	(1,000 metric tons)	(US\$ million)		(1,000 metric tons)		(US\$ million)		
4.88	0	6.6	67.9	2.94	3.24	0	0.87	0.00	-0.15	2.22
4.88	25	6.6	62.9	3.04	3.24	13	0.76	0.34	-0.15	2.09
4.88	50	6.6	58.4	3.17	3.27	26	0.65	0.68	-0.15	2.00
4.88	75	6.6	54.3	3.34	3.31	38	0.53	1.03	-0.15	1.94
4.88	100	6.6	50.7	3.54	3.38	51	0.42	1.37	-0.15	1.90
4.88	150	6.6	44.9	3.89	3.51	77	0.20	1.99	-0.15	1.86
4.88	200	6.6	40.5	4.30	3.70	103	-0.02	2.59	-0.15	1.88
4.88	250	6.6	37.1	4.73	3.92	127	-0.24	3.16	-0.15	1.96
4.88	300	6.6	34.5	5.18	4.17	152	-0.45	3.69	-0.15	2.09
4.88	350	6.6	32.5	5.60	4.43	176	-0.66	4.17	-0.15	2.24
4.88	400	6.6	30.9	6.00	4.71	199	-0.86	4.60	-0.15	2.41
6.80	0	9.0	62.7	2.09	3.09	0	0.87	0.00	-0.51	1.73
6.80	25	9.0	57.9	2.23	3.10	13	0.76	0.34	-0.51	1.63
6.80	50	9.0	53.6	2.40	3.13	26	0.65	0.69	-0.51	1.57
6.80	75	9.0	49.8	2.60	3.19	38	0.54	1.04	-0.51	1.54
6.80	100	9.0	46.4	2.83	3.26	51	0.42	1.38	-0.51	1.53
6.80	150	9.0	41.1	3.21	3.41	77	0.20	1.99	-0.51	1.52
6.80	200	9.0	37.0	3.64	3.61	102	-0.02	2.59	-0.51	1.58
6.80	250	9.0	33.9	4.09	3.85	127	-0.23	3.15	-0.51	1.68
6.80	300	9.0	31.5	4.54	4.11	151	-0.44	3.66	-0.51	1.83
6.80	350	9.0	29.7	4.95	4.38	175	-0.65	4.12	-0.51	1.99
6.80	400	9.0	28.4	5.35	4.66	198	-0.85	4.54	-0.51	2.18
9.37	0	12.1	56.3	1.10	2.90	0	0.87	0.00	-0.92	1.14
9.37	25	12.1	51.8	1.28	2.93	13	0.76	0.35	-0.92	1.08
9.37	50	12.1	47.8	1.50	2.97	25	0.65	0.70	-0.92	1.06
9.37	75	12.1	44.3	1.74	3.04	38	0.54	1.05	-0.92	1.07
9.37	100	12.1	44.1	2.00	3.12	51	0.42	1.40	-0.92	1.09
9.37	150	12.1	36.4	2.41	3.29	77	0.20	2.00	-0.92	1.13
9.37	200	12.1	32.8	2.87	3.52	101	-0.01	2.58	-0.92	1.22
9.37	250	12.1	30.0	3.35	3.77	126	-0.23	3.13	-0.92	1.36
9.37	300	12.1	27.9	3.79	4.04	150	-0.43	3.61	-0.92	1.53
9.37	350	12.1	26.4	4.20	4.33	173	-0.63	4.04	-0.92	1.71
9.37	400	12.1	25.3	4.58	4.63	196	-0.83	4.44	-0.92	1.90
13.10	0	16.4	48.0	-0.10	2.67	0	0.87	0.00	-1.38	0.42
13.10	25	16.4	44.0	0.14	2.71	13	0.76	0.36	-1.38	0.41
13.10	50	16.4	40.4	0.42	2.78	26	0.65	0.71	-1.38	0.44
13.10	75	16.4	37.2	0.71	2.87	38	0.53	1.07	-1.38	0.49
13.10	100	16.4	34.4	1.02	2.97	51	0.42	1.42	-1.38	0.56
13.10	150	16.4	30.4	1.49	3.18	76	0.21	2.01	-1.38	0.65
13.10	200	16.4	27.4	1.99	3.43	100	-0.00	2.58	-1.38	0.80
13.10	250	16.4	25.1	2.46	3.71	124	-0.21	3.08	-1.38	0.98
13.10	300	16.4	23.5	2.90	4.00	147	-0.41	3.53	-1.38	1.16
13.10	350	16.4	22.3	3.30	4.29	170	-0.61	3.93	-1.38	1.36
13.10	400	16.4	21.6	3.65	4.60	191	-0.79	4.27	-1.38	1.56

Table 21—Trade-offs with price elasticity equal -0.2

Trade-off	Standard Deviation of Price			
	17.0	12.2	9.1	6.5
	(US\$1,000/year)			
Cost per 1,000-metric-ton decrease in average annual imports				
As imports decline from 44,000 to 34,000 metric tons				
Price bands	93	100	130	152
Optimal policies	90	110	134	153
Cost per US\$ decrease in standard deviation of price				
When average annual imports equal 44,000 metric tons				
Price bands	...	299	317	314
Optimal policies	...	345	385	435
When average annual imports equal 34,000 metric tons				
Price bands	...	341	375	395
Optimal policies	...	387	463	506

Table 22—Trade-offs with production variability equal 12 percent

Trade-off	Standard Deviation of Price			
	16.4	12.5	9.1	6.9
	(US\$1,000/year)			
Cost per 1,000-metric-ton decrease in average annual imports				
As imports decline from 50,000 to 40,000 metric tons				
Price bands	98	116	146	161
Optimal policies	84	105	129	142
Cost per US\$ decrease in standard deviation of price				
When average annual imports equal 50,000 metric tons				
Price bands	...	409	424	478
Optimal policies	...	459	522	571
When average annual imports equal 40,000 metric tons				
Price bands	...	451	515	544
Optimal policies	...	514	593	687

APPENDIX 2: PSEUDOCODES FOR PRICE BAND AND OPTIMIZATION PROGRAMS

Pseudocode for price band simulation program

```
Compute  $Q_{\max}$  and  $Q_{\min}$ 
Loop for number of cycles
 $t = 0$ ,  $S_0 = 100$ 
Loop for number of years in cycle
  Random selection of  $WP_t$  and  $Q_t$ 
  If  $Q_t < Q_{\min}$  then
     $NP_t = Q_t - Q_{\min}$ 
  Else
    If  $Q_t > Q_{\max}$  then
       $NP_t = Q_t - Q_{\max}$ 
    Else
       $NP_t = 0$ 
    Endif
  Endif
   $S_t = S_{t-1} + NP_t$ 
  If  $S_t < 0$  then
     $M_t = -S_t$ 
     $S_t = 0$ 
  Else
    If  $S_t > S_{\max}$  then
       $X_t = S_t - S_{\max}$ 
       $S_t = 0$ 
    Else
       $X_t = 0$ 
       $M_t = 0$ 
    Endif
  Endif
  Compute all costs
  If  $t = 10$  then
    Add replace stock charges
    Add all costs to summary variables
  Endif
Next year in cycle
Next cycle
Produce printout
```

Pseudocode for optimization program

```
*First section computes cost-to-go in final year
Loop for each possible state of the world (WP, Q, S)
 $GC_{min} =$  a very large number
Loop for each possible combination of control variables (NP, X, M)
  If this is realistic control combination for this state, then
    Compute GC for this state and control
    If  $GC < GC_{min}$  then
       $GC_{min} = GC$ 
    Endif
  Endif
Next control
Next state
*Next section does the backward recursion
Loop for each year, beginning with final year
Compute  $E(GC_{t+1} | S_t)$ ; that is, the expected costs in future years of carrying out
 $S_t$  in the present year
```

This equals the sum of GC_{min} for each particular stock level, the GC_{min} 's being weighted by the probability of that production level and world price occurring.

```
Loop for each possible state of the world
   $GC_{min} =$  a very large number
  Loop for each possible combination of control variables
    If this is a realistic control for this state, then
      Compute GC for this state and control
      If  $GC + E(GC_{t+1} | S_t) < GC_{min}$  then
         $GC_{min} = GC + E(GC_{t+1} | S_t)$ 
      Endif
    Endif
  Next control
Next state
Next year
*Next section does simulation of optimal policy
Loop for number of cycles
 $t = 0, S_0 = 100$ 
Loop for number of years in cycle
  Random selection of  $WP_t$  and  $Q_t$ 
  Interpolation of optimal policy to compute proper values of
   $NP_t, X_t$ , and  $M_t$  given  $WP_t, Q_t$ , and  $S_{t-1}$ 
  Compute all costs
```

If $t = 10$ then
 Add replace stock charges
 Add all costs to summary variables
Endif
Next year in cycle
Next cycle
Produce printout

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RICE PRICE FLUCTUATION AND AN APPROACH TO PRICE STABILIZATION IN BANGLADESH

Raisuddin Ahmed
Andrew Bernard

February 1989

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RICE PRICE FLUCTUATION AND AN APPROACH TO PRICE STABILIZATION IN BANGLADESH

**Raisuddin Ahmed
Andrew Bernard**

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FOREWORD

Correction of the distorted structure of relative prices and prevention of wide fluctuations in the level of commodity prices constitute twin challenges in agricultural price policies. While macroeconomic instruments are commonly used in changing relative prices, the task of price stabilization requires comprehensive sectoral analysis of price relations, stock requirements, market integration, and various other factors that destabilize supply and demand.

IFPRI's initial analyses of price stabilization were limited to the issue of optimal stock of foodgrains. Thomas Pinckney's work on stock policies in Kenya and Pakistan and Raj Krishna and Ajay Chhibber's research on India have demonstrated how optimal stock policies can save scarce public resources so urgently required for economic development.

This research report by Raisuddin Ahmed and Andrew Bernard focuses less on optimal stock and more on a consistent framework and operational rules for stabilization of prices. It examines the factors that cause fluctuation in prices and develops a framework for containing annual and seasonal variation of prices within a bound. Although the research is conducted in the context of Bangladesh, the approach is applicable to other countries. IFPRI is currently involved in extending this research by applying it in Bangladesh through a collaborative arrangement with the Bangladesh Ministry of Food. Such a link between research and application will bring IFPRI's research directly to bear on the policy needs of developing countries, improving both current policy and future research.

John W. Mellor

Washington, D.C.
February 1989

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This study was initiated to examine fluctuations in rice prices of Bangladesh, where policymakers have regularly experienced frustration with the management of prices of this critical commodity. The repeated shifts from a position where they fought to contain upward price movement to another where they confronted the task of stemming the downward dash of prices have puzzled them. The absorbing nature of the task has diverted attention from issues and problems of long-run development.

Our deepest gratitude goes to all those public officials in Bangladesh who shared their experiences and understanding in unfolding the problems of price stabilization in Bangladesh. It is hoped that the study will help solve the puzzle and provide a basis for removing the frustrations.

The final version of the study reflects the assistance of many who provided access to data, commented on earlier drafts, and extended guidance in the analytics of complicated measurement. While we express our general appreciation to all those involved in such assistance, particular recognition of extremely useful help goes to Romeo Bautista, John W. Mellor, Robert Nevin (USAID, Dhaka), Mahabub Hossain (BIDS, Dhaka), R. R. Piggot (Australia), Stephen Vosti, Mustapha Rechache, and a number of anonymous reviewers.

Raisuddin Ahmed
Andrew Bernard

SUMMARY

Traditional welfare economists often conclude that commodity price stabilization schemes are economically wasteful. Nevertheless, most contemporary developing countries use some type of stabilization policy to address price instability arising from shocks in the domestic supply of foodgrains. They do so because the assumption that consumers can save enough in times of low prices to pay for higher prices later on is unrealistic in economies with widespread poverty and imperfect capital markets. The positive and comprehensive dimensions of stable prices are considered in this report.

This report examines the sources and extent of rice price variability in Bangladesh and provides a complete framework for the implementation of a simple yet effective mechanism for limiting that variability in the future. Although the framework is developed in the context of Bangladesh, the general approach should be applicable for most developing countries.

Annual price fluctuations in the postindependence or posttechnology period in Bangladesh have increased, and supply and demand forces in the rice market no longer move together to stabilize prices. In addition, imports that are controlled by the government have taken on a new, more important role in helping to stabilize prices. These developments will significantly affect the actual implementation of a price-targeted program in Bangladesh. If, as is indicated, supply shocks are becoming more important than demand shifts as a source of price variability, then government action on the supply side has to diminish rather than augment price variability. To do this, a timely mechanism to respond to any dramatic shortfall in production (for example, crop loss from natural calamity) should be developed and put into action. The coordination of imports with a national stocking policy is a critical element in any rice price program in Bangladesh. Imports can provide long-term access to sufficient amounts of foodgrains, whereas the stocks on hand offer shorter-term and location-specific responses to foodgrain deficits.

While the structure of the overall economy of Bangladesh has been changing, so too has the rice market itself undergone dramatic shifts in recent years. New high-yielding varieties of rice have increased overall production and have changed the intrayear pattern of production and prices. Where once the aman crop dominated the annual production of rice, now the large boro and aus crops, especially the high-yielding varieties, cause prices to fall back almost to their December (aman) levels. This new pattern of seasonality has implications for the government's role in the procurement and distribution of foodgrains. A second procurement season in the regions growing rice in the boro and aus seasons is likely to be required if a price-based program of stabilization is adopted.

Although most of this study focuses on temporal aspects of prices in the rice market, spatial relationships should not be overlooked. The analysis of market integration shows that, although transmission of prices does occur to some degree in all markets at certain times in specific locations, the integration of markets is not complete. This implies that particular attention should be paid to those markets that are not well linked to the overall rice economy, and procurement and sales procedures should be adjusted accordingly. Special attention should be given to the districts of Patuakhali, Barisal,

Dinajpur, Rajshahi, and Rangpur in procuring the aman crop. Similarly, Chittagong, Kushtia, and Jessore should get special attention during the aus season.

The framework for price stabilization implies a planning shift from a quantity-targeted to a price-targeted approach in the management of the public food system. The model developed specifies a price band in annual prices and links this band to the seasonal prices, keeping in view both cost and price stability. The price band in effect eliminates both super- and subnormal profits from private trade operations in foodgrains. The results indicate that a successful price stabilization program will substantially reduce pressure on the rationing system, and the process can be even more effective if pricing of rationed foodgrains, particularly ration prices for priority groups, is coordinated with market prices. A simulation exercise shows that if the proposed mode of stabilization had been operative during 1976-84, the fluctuation in annual prices would have varied from 3.4 to 23.1 percent, compared with variations of -17.3 to 41.3 percent under the existing system. Seasonal prices vary by a stable 15 percent every year under the proposed model, compared with actual prices, which varied from a low of 13.8 percent in 1980/81 to a high of 37.8 percent in the following year.

INTRODUCTION

Stabilization of prices, particularly of major foodgrains, is a serious concern of most developing countries. There are two types of temporal variations in prices: interyear and intrayear. The intrayear variation is generally called the seasonality of prices. The distinction between the two types is important in the context of policy instruments that are brought to bear on prices in order to contain extreme fluctuations. Public procurement in the harvest season and sales in the peak-price season are well-known policy instruments for combating seasonal fluctuations in foodgrain prices. Similarly, buffer stocks and export and import policies in foodgrains are commonly used to manage interyear variations in food prices and supply. Many developing countries spend a substantial share of their budgetary and administrative resources in controlling these temporal variations in prices. Therefore, issues and relations underlying price fluctuations need to be properly understood before formulating and implementing such costly policies.

The understanding of price stabilization problems and their potential solutions requires the following information. First, it is necessary to identify and examine conceptual issues involved in the assessment of benefits and costs and the underlying analytic approach of price stabilization. Second, the extent and nature of instability in prices of a commodity have to be quantitatively estimated, disentangling the real from nominal effects. Third, the underlying causes of unstable prices have to be identified in order to determine the influence of random elements as opposed to systematic factors. Fourth, before formulating any public stabilization policy, it is essential to know whether markets where private traders operate are integrated. If markets are not integrated, then many assumptions of aggregate analysis (for example, estimates of supply and demand parameters from aggregate relations) are violated. Finally, to make this information useful for practical operation, it is desirable to formulate an approach to price stabilization appropriate within a specific context. These are the objectives of this study for Bangladesh.

Price stabilization is essentially a short-run problem. Therefore, the policy instruments chosen should reflect the contemporary situation and pragmatic considerations. But probing into the dynamics of current situations by examining the historical behavior of prices in relation to structural changes in the economy is virtually unavoidable. Thus it is necessary to look backward as well as forward. Three particular aspects of Bangladesh's history receive specific analytic attention here. The first relates to the transition from a predominantly subsistence economy to a moderately commercialized one and the implications of that for variability in prices. The second relates to the effect of modern high-yielding varieties (HYVs) of rice on seasonality of prices. The third concerns data as well as behavior of price regimes before and after Bangladesh achieved independence in 1971.

Serious problems exist in pursuing price analysis covering the period 1971 through 1974, years of extraordinary social and economic disruptions in Bangladesh. Similarly, statistics such as personal income, imports, and money supply for the 1960s, when Bangladesh was a part of Pakistan, are suspect. Because of these problems, the analysis may seem unbalanced to readers who are not conversant with Bangladesh, but they are real issues that deserve to be explicitly recognized.

Methodology

To achieve the objectives of the study, four main methodological steps are necessary. First, nominal prices are decomposed into trend, seasonal, and irregular components. Second, causes of price movements are analyzed. Third, the degree of market integration is measured, and fourth, target annual average prices are predicted, and the annual average is linked with the seasonal factors to arrive at seasonal target prices for stabilization. These methods are explained in the sections where each task is discussed.

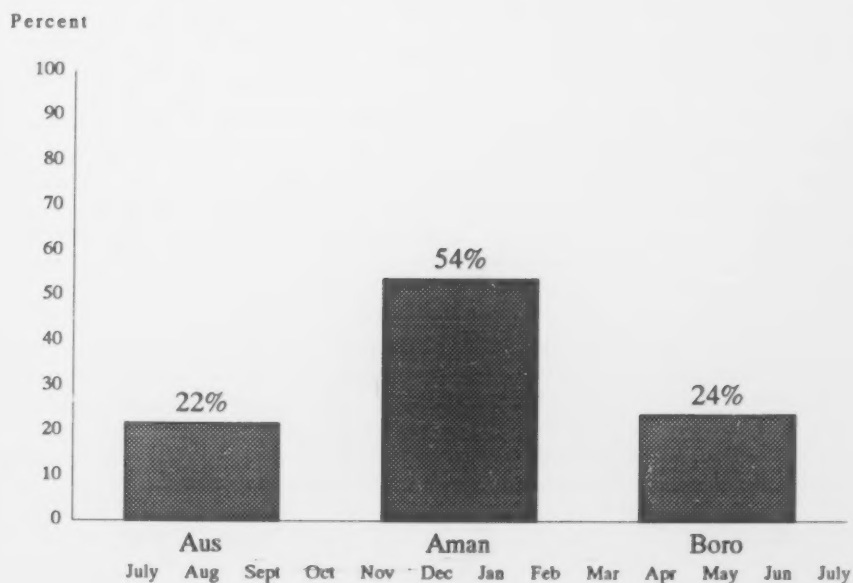
Data

The data used in the analyses are the wholesale monthly prices of coarse varieties of rice collected by the Department of Agricultural Marketing of the government of Bangladesh. Government price data include prices for three qualities of rice: fine, medium, and coarse. With the adoption of HYVs of rice, which are all coarse quality, the share of coarse rice in the total rice supply has increased. Currently coarse rice has the largest share, and coarse and medium rice together compose more than 90 percent of rice supply in the market. The use of coarse rice prices here should not invalidate the conclusions on the behavior of rice prices in general. The prices of various qualities of rice are closely correlated. The simple correlation coefficient between prices of coarse and medium-quality rice during 1975-84 is 0.9986 and highly significant. However, in a rising phase of rice prices, the price of coarse rice rises slightly faster than the price of medium. Similarly, in a falling phase, the price of coarse rice declines faster than the price of medium rice. As prices change, consumers in the middle-income bracket who shift back and forth between the two qualities of rice cause this phenomenon.

The national average price of any given quality is based on prices of about 350 markets spread throughout Bangladesh. However, the average is not weighted to reflect the size of the share of each market. Nor does the average explicitly reflect the various types of rice that are produced and marketed in various seasons. There are three seasons for rice harvests—aus, aman, and boro. The span of harvest time and the share of production for each of the three types of rice are shown in Figure 1.

The share of harvest for each season is shown as a flat figure even though arrival at market or actual harvest is concentrated in certain months, depending on the location. Generally, the aus harvest is concentrated in July-August, aman in December-January, and boro in May-June. Most rice grown in the aus season is coarse rice. Moreover, rice harvested in this season generally has a high moisture content; therefore, prices quoted in the market could vary widely due to varying degrees of moisture. Local varieties of rice harvested in aman and boro seasons consist of fine, medium, and coarse varieties.

Figure 1—Time spans of harvest seasons of rice and shares of aus, aman, and boro season harvests in total rice harvest, averages for 1982-84



Source: Computed from data in Bangladesh, Bureau of Statistics, *Statistical Yearbook 1985/86* (Dhaka: BBS, 1986).

PRICE STABILIZATION ISSUES

Whether price stabilization is economically rational or not is a fundamental issue. Economists approach this issue by comparing economic benefits from a stabilization program with its cost. But in fact most low-income, developing countries, including Bangladesh, operate some sort of stabilization program, particularly in foodgrains, even if such programs are frequently wasteful. To ask them to dismantle the programs has not been effective in the past and is not expected to be so in the near future. This is partly because unstable prices have political consequences and partly because policy-makers are concerned about the effects of periodic food scarcity, which can result in starvation and serious malnutrition. In addition, occasional sharply falling prices during harvest season can undermine the confidence in markets of producers and policymakers. Therefore, logic dictates a need for a stabilization mechanism that would minimize economic waste but preserve the elements that address food security and price support concerns arising from severe price instability. This is the approach taken in this study on rice price stabilization in Bangladesh. Until empirically tested alternatives to price stabilization are available, the emphasis on improvement of the operation of stabilization programs seems valid.

Even though this approach has been adopted here, the standard analysis of benefits and costs of stabilization is not irrelevant. The theoretical framework used historically in most empirical investigations of commodity price stabilization is the simple Marshallian partial equilibrium analysis of a closed economy developed by Waugh (1944) and Oi (1961) and synthesized by Massell (1969, 1970). Such a simple model is often inadequate for empirical application in dynamic circumstances, but it captures elemental effects of stabilization. However, some economists have raised serious doubts about the use of this approach in empirical investigations. Cochrane (1980) argues that "welfare analysis based upon the concepts of consumer and producer surplus has not in the past made, and will not in the future make, any recognizable contribution to the making of decisions by the United States, other developed countries, the less-developed nations, or the international agencies either to initiate commodity stabilization programs or to reject them." The use of the concepts, however, persists in economic analyses because neat alternatives are absent.

The assumption of a closed economy in the application of the concept is not considered a serious constraint. Most developing countries, Bangladesh in particular, do not allow open external trade in foodgrains even though they depend on public imports or exports to cushion the stocks of foodgrains. This control of foodgrain trade by the public sector makes the closed-economy model relevant. A brief exposition of the partial-equilibrium model is presented below.

Figures 2-5 indicate the income and welfare effects of price stabilization. Figure 2 shows a standard linear supply-demand relationship with two equally probable supply curves— S_1 and S_2 . The third curve, S_3 , represents an average of the other two. With supply fluctuating between the two extremes over time and without price stabilization, producers' average revenue is $(OP_2 \cdot OQ_2 + OP_1 \cdot OQ_1)/2$. Upon intervening, the government or buffer stock agency would buy Q_0Q_4 in the period of high supply (S_1) to maintain price at P_0 , whereas it would sell Q_0Q_1 during a poor harvest (S_2). In this

Figure 2—Welfare effects with linear supply-demand relations

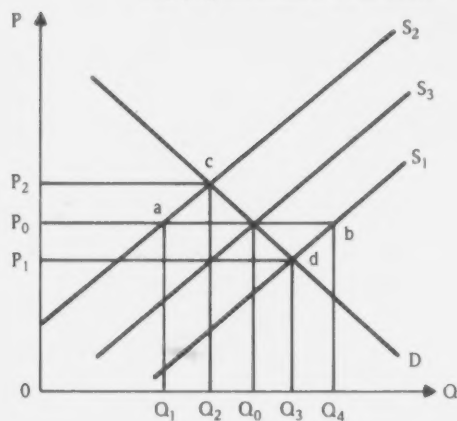


Figure 3—Welfare effects with shifting supply curve

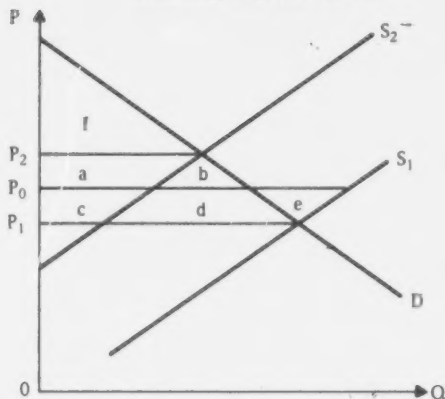


Figure 4—Welfare effects with shifting demand curve

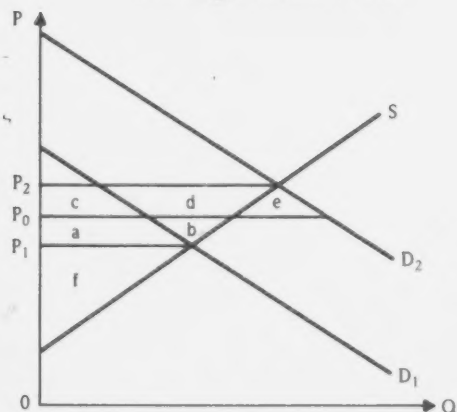
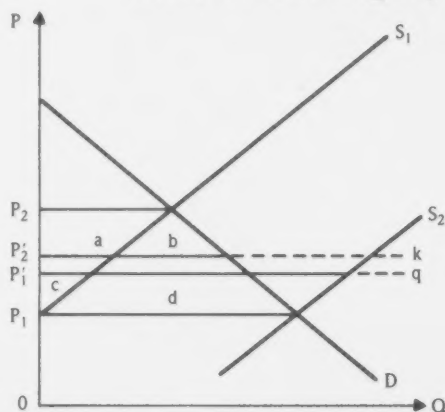


Figure 5—Welfare effects including cost of buffer stock agency



case price stabilization raises the variability of gross revenue while at the same time increasing its mean. Following this static framework, Waugh's 1944 seminal work established that consumers having a negatively sloped demand curve gain from price variation and lose from price stabilization. He focused only on consumers. Following Waugh's line of reasoning, Oi (1961) demonstrated that with a positively sloped supply curve producers also benefit from price instability and lose from stabilization. He focused only on producers. Massell (1969) combined both producers' and consumers' welfare and illustrated that the distribution of welfare changes is determined by the origin of the random price fluctuation, and that price stabilization produces a net gain to the society (producers and consumers taken together).

Massell uses the linear model with prices fluctuating from shifts in either supply or demand or both, with stabilization being implemented through a buffer stock. Figure

3 shows the case of shifting supply, with supply curves S_1 and S_2 each occurring 50 percent of the time. The price P_0 is a price that can be achieved with costless storage activity, that is, P_0 is the buying and selling price of the buffer stock agency (this unrealistic assumption of costless storage is relaxed below). By preventing the price from falling to P_1 , producers gain revenue $(c + d + e)$, while consumers lose $(c + d)$, so that there is a net gain in the system of e . Preventing the price from rising to P_2 benefits consumers by $a + b$ and costs producers only a in forgone revenue, and there is a net gain of b . Hence stabilization gives producers a net gain of $c + d + e - a$ and consumers a net loss of $c + d - a - b$. Therefore the total net gain by producers and consumers together is $e + b$. Massell (1969) notes the welfare problems associated with this type of abstraction but remarks that "...producers are able to compensate consumers so as to leave both groups better off."

Figure 4 shows price fluctuations resulting from demand shifts from D_1 to D_2 (again each curve is equally likely). Mirroring the supply movement, the net gain to consumers is $c + d + e - a$, and the net loss to producers is $c + d - a - b$, so that the overall gain equals $e + b$. The model incorporates positive storage costs (Figure 5) when the buffer stock agency operates to stabilize prices within a range of $P_1 P_2$ so that it earns a profit of $P_2 - P_1$ on each unit bought or sold. These profits can be used to offset storage, interest, insurance, and other costs of maintaining stocks. In Figure 5, $P'_2 = k$ and $P'_1 = q$ are costs per unit when the level of stabilization is set at P'_2 and P'_1 , respectively. Since costs exist, partial price stabilization will be closer to optimal than absolute price stabilization within the context of this model.

Turnovsky (1974) points out that the Waugh-Oi-Massell analysis assumes that demand and supply depend upon actual prices and deal with "a situation of price variability rather than price uncertainty, since an important aspect of this latter case is the fact that some decisions must be made on the basis of imperfect information." Turnovsky examined the Waugh-Oi-Massell approach under the more realistic assumption that producers' decisions were based on expected prices, and he considered two different processes by which producers anticipate prices—rational expectations and adaptive expectations. He found that whether or not the Oi results continue to hold depends on the price expectation mechanism as well as the autoregressive properties of the stochastic disturbances, while the Waugh and Massell results hold under both expectation hypotheses.

Although a number of researchers have pointed out various shortcomings of the static model, Newbery and Stiglitz (1981) provide a more comprehensive framework for examining welfare issues related to commodity price stabilization. Some important issues that they focus on will be examined here in the context of Bangladesh and the implications of economic models. In general, Newbery and Stiglitz are against public stabilization policies even though they find occasional positive gains.

Does Price Stabilization Destabilize Income?

Income from the crop is the product of its price times the quantity, PQ . Generally price and quantity are inversely related; price rises when production falls, and price falls when production rises. This relation is apparent in annual data of Bangladesh. Assuming a constant elasticity of demand, ϵ , the relation between variability of income (Y) and price is $\text{var}(\log Y) = (1 - 1/\epsilon)^2 \text{var}(\log Q)$. When price is absolutely stabilized, the only source of variability in income is production. Whether price stabilization reduces or increases variance in income depends on whether price elasticity of demand is greater or less than 0.5 in absolute terms and on the extent of marketed surplus.

When price elasticity of demand is 1.0, the variance in income is zero. When price elasticity of demand is less than 1.0 but greater than 0.5 and supply fluctuation is the source of price fluctuation, then stabilization of prices increases instability in income from the particular crop. Of course, supply is generally the source of variability in prices of rice in Bangladesh (that is, variability of imports and domestic production), and the price elasticity of demand for rice ranges from 0.4 to 0.6 (Pitt 1983, Ahmed 1981). This suggests that price stabilization in rice may increase instability in income from rice. But such a conclusion could be quite misleading in a dynamic sense.

The effects of rice price instability on jute prices and other sources of income are not zero for Bangladesh. The positive relations between the rice price and nominal wage rates, as well as various other prices, have been recorded in other studies (Ahmed 1981). These relations indicate that variability in nominal income from rice may rise with stabilization, but variability of real income as well as total household income is likely to be smaller with rice price stabilization than without it. Perhaps these dynamic factors led Newbery and Stiglitz (1981) to conclude that "the benefits of pure price stabilization schemes are likely to be relatively more important for small countries and likely to be greater in total, the more widespread is the production of the commodity." Rice is clearly a dominant crop in the agriculture of Bangladesh.

Farm Structure and Implications for Price Stabilization

The structure of farms in Bangladesh is such that 40 percent are deficit farms cultivating less than 1.0 acre each. They are deficit in the sense that they are net buyers of rice even in good harvest years. Another 30 percent, cultivating an area between 1.0 and 2.5 acres per household, are marginally self-sufficient in that, as a group, in good years they produce a small marketable surplus (see Table 1), but they may have to buy rice in bad harvest years. The remaining 30 percent of farms are surplus producers of rice in good years as well as bad. About 91 percent of the marketable surplus of rice is produced by this group, which fits the conventional definition of "producers" in the neoclassical framework of price analysis.

On the basis of farm size data for 1973/74 through 1977/78 from a study by Ahmed (1981), the relation of marketable surplus to gross production and prices is as follows. With a 1.00 percent change in rice production, the marketable surplus changes

Table 1—Share of farm groups in the total number of farms, in total area cultivated, and in marketable surplus

Farm Group	Share of Total Farm Households, 1983	Share of Total Land Area, 1983	Share of Marketable Surplus in Total Production, 1978
		(percent)	
Deficit farms (less than 1.0 acre)	40.4	7.8	0.0
Marginally self-sufficient (1.0 to 2.5 acres)	29.9	21.2	3.3
Surplus (more than 2.5 acres)	29.7	71.0	91.7

Source: Computed from Bangladesh Bureau of Statistics, *National Report on the 1983/84 Census of Agriculture and Livestock* (Dhaka: BBS, 1986).

in the same direction by 2.20 percent in the marginally self-sufficient group and by 1.50 percent in the surplus farm group. The overall elasticity is 1.56. With a 1.00 percent change in the rice price, the marketable surplus changes by 0.02 percent in the same direction, but only in the surplus farm group. In the marginally self-sufficient group, the price effect is not significant; even the direction is negative. This implies that such self-sufficient farms may have a backward-bending but weak supply curve. Such farmers can fulfill their cash obligations by selling a smaller quantity of rice when the price is high rather than a larger amount when the price is low.

On the basis of the foregoing relations and assuming a price elasticity of demand for rice of -0.5 and 1983/84 production, price, and marketing rates, the estimated benefits from price stabilization, following the short-run static framework, are shown in Table 2. The source of price change is entirely the random supply instability.

The estimates are based on a gross production level of 16.0 million tons of rice in 1983/84 and 4.6 million tons of marketable surplus. The price assumed is 260 taka (Tk) per maund.¹ This is the base from which changes are measured. Note that the magnitude of change is the main concern and the parameters of change are important in these measurements. The base-year statistics are of secondary importance.

The effects are drawn from short-run relations but the lessons derived from this simple exercise go far beyond the ones indicated by the economists mentioned earlier.

Effects on Consumers

The analysis in Table 2 and similar past analyses show that price stabilization is bad for consumers because consumers bear a net loss (Tk 26.1 million in Table 2). But the experiences of developing countries indicate that it is the consumer who demands price stabilization. Why this gap between reality and economic analysis? The source of this conflict between economic analysis and empirical experience may be found in the averaging of good and bad seasons. The economic analysis implies that a rational consumer, who saves when prices are low, enabling him to purchase when prices are high, is on average better off with price instability. In reality this does not happen where the level of poverty is high and capital markets are imperfect. An unsatiated consumer cannot hold back on consumption sufficiently during a low price season to save enough to help him avoid starvation in a high price season. He cannot plan with a time horizon that includes the two price situations, and therefore an average of the two situations is not applicable to him. The process of adjustment to a high price-low income situation in a country with widespread poverty may have further implications for future growth. A study by Jodha (1978), based on the Rajasthan drought, indicates that the affected population first reduces consumption, then defers committed obligations and reschedules current production activities. As the shock becomes more severe, they deplete inventories, livestock, and utensils; mortgage or sell land; and finally migrate to urban centers or other areas. Replacement of assets in good years becomes difficult not only because they can save little in good years but also because they have to sell cheap and buy dear. A study in Bangladesh records a similar process of adjustment by the poor (Ahmed 1981).

Price instability, therefore, has the potential for accelerating the process of pauperization. Price stabilization schemes, if implemented effectively, can reduce the effect of this process. In essence, such schemes impose discipline upon the consumer so that he consumes less when prices fall. Such schemes also prevent consumption from falling

¹ One maund equals 37.32 kilograms. At the 1984/85 official rate of exchange, US\$1.00 = Tk 30.

Table 2—Estimated short-run gains to producers and consumers from price stabilization, 1983/84

Types of Consumers and Producers	Low-Price Season ^a	High-Price Season ^a	Net Loss or Gain Over Two Seasons
	(Tk million)		
Consumers	-349.40	323.27	-26.13
Producers:	403.88	-270.93	132.95
Deficit farms ^b	0.00	0.00	...
Marginally self-sufficient farms	35.36	-20.49	14.87
Surplus farms	368.52	-250.44	118.08

Sources: Estimated on the basis of parameters in Table 2, and production data from Bangladesh, Bureau of Statistics, *Statistical Yearbook of Bangladesh 1985* (Dhaka: BBS, 1985).

Note: Minus sign indicates a loss.

^a The low price season is when production increases by 10 percent without a change in demand, and the high price season is when production falls by 10 percent.

^b Deficit farms are net buyers, so the effect of price stabilization on this group is included in the consumer category.

precariouly when prices rise. Because of an adverse economic environment, a poor consumer will fail to follow the same rational consumption path as that implied in price stabilization if left alone to face market forces.

Effects on Producers

Table 2 reveals some interesting facets of price stabilization relevant to producers. Again, the average of good and bad harvest seasons masks a significant effect of price stabilization. It is clear from the numbers that the deleterious effect on producers of a price slump in a good harvest season is much larger than the beneficial effect when the harvest is poor and prices are high. This adverse effect in a falling price regime, in the absence of a stabilization scheme, is about 47 percent larger than the positive effect for surplus farmers during a rising price regime. For marginally self-sufficient farmers the deleterious effect of low prices is 75 percent larger than the positive effect of the high price scenario. In Bangladesh, when agricultural technology is progressing vigorously, the downward fluctuations tend to be more numerous, albeit less severe, than upward fluctuations, as will be shown later. This makes the case for stabilization much more convincing for a technologically oriented growth strategy than for traditional agriculture. Therefore, price stabilization, particularly price supports when harvests are good, should be a critical concern of producers with a marketable surplus.

Finally, the assumption that all farmers are net surplus producers of rice is not correct for Bangladesh. It is wrong to assume that the effect on deficit farmers is the same as that on consumers. These deficit farmers in practice sell some rice just after harvest at low postharvest prices to meet urgent cash obligations. They then must buy more during other seasons when prices are higher. They have little access to the formal credit market to avoid this situation (see Ahmed and Hossain 1988).

Rice Price Stabilization and Jute Production

One important issue raised by Newbery and Stiglitz (1981, 27) concerns the effect of price stabilization in one crop on production of and income from other crops. In the context of Bangladesh, the effect of rice prices on jute production deserves particular attention.

In 1981-84 jute area constituted only about 4 percent of gross cropped area, compared with rice, which covered about 80 percent. As a result, a change in relative prices of rice and jute caused a much sharper change in jute production than in rice production. Estimates of short-run supply elasticity of jute range between 0.50 and 0.60, while those for rice range between 0.07 and 0.15 (Rahman 1986). Only a small part of the tiny price elasticity of rice can be attributed to jute, whereas most of the price response in jute is attributable to rice. The substitutability of the two crops in land use and the difference in technological progress between the two are the causes. Thus, rice price stabilization contributes to jute price stabilization, but jute price stabilization has little effect on rice price stability. Analyzing rice price stabilization without treating jute explicitly does not change the conclusion on rice prices substantively.

Thus, rice prices should enter into any program that attempts to stabilize jute prices. Although stabilization of jute prices has continued to be an ineffective and expensive venture, the government has not been able to forsake the idea of jute price stabilization completely. It has been observed that the instability in prices and supply of jute has contributed to the loss of world demand for Bangladesh's jute as much as the competition from synthetic substitutes (Kibria 1985). The uncertain supply of jute has eroded the confidence of foreign buyers. Switches from jute to synthetics in times of shortage and high price are asymmetrical in the sense that a reverse movement during a glut in supply and low prices does not occur. Rice price stabilization would therefore exert a positive influence on jute price stability and jute supply.

Cost of Stabilization

Perhaps the cost of stabilization ought to be the main concern, not suspicion about its beneficial effects. Even in this area, there are three distinct issues that must be carefully analyzed to calculate the cost of a stabilization program.

First, looking back to Figure 2, a static analysis would show that a stabilization agency would have to procure the quantity Q_0Q_4 during a good harvest season and to sell from its stock quantity Q_0Q_1 on the open market during a poor harvest year. Therefore, the average stock and cost of the operation would be determined by these quantities. The operation costs would include the interest cost of the financial capital required to purchase and sell the stock, transport and handling charges, rent of physical storage facilities, and any wastage of stock that may occur in the operation. Of these, the interest cost is by far the largest component, and it is dependent on the quantity procured and distributed.

In real-world operation, the actual stock to be maintained for price stabilization would be substantially different from the average of Q_0Q_1 and Q_0Q_4 shown by Figure 2. The difference arises from the behavior of private traders, including surplus farmers. If these traders and farmers expected that the government, for budgetary or other reasons, could not maintain the price at the announced level, they might speculate against the government position by postponing, selling, or unloading all their stock on the market to make larger profits. Such behavior by farmers and traders implies that the government would have to buy or sell more than the quantity estimated on the basis of no change in the expectations of producers and traders. It may be noted in Table 1 that only about 30 percent of producers produce virtually all of the marketable surplus. Such concentration of marketable surplus implies that the expectation of—not necessarily collusion within—this relatively small group can create severe instability in market prices of rice. Therefore, stability in the government's actions is an important

factor in conditioning traders' and farmers' expectations and potentially reducing the costs of a program. In any case, such fine-tuning may never be perfect. Actual stock for price stabilization, and therefore the cost, may have to be larger than indicated by the static models mentioned earlier.

Second, explicit budgetary costs of the ongoing procurement and distribution of foodgrains are often assumed to be the costs of price stabilization, but this is often not a true assessment. Frequently this budgetary cost includes the cost of food subsidy as well as the cost of stabilization. It is important that the two elements be separated in order to determine the pure cost of stabilization.

Third, if the two objectives of transfer of income through food subsidy and price stabilization are attempted through the same program, as is usually the case, then the treatment of cost for stabilization requires a different approach than is conventionally followed. The administrative cost, physical storage cost, and part of the stocking cost that are required for transfer of income through food subsidy can be assumed to be fixed costs that a government will carry in any case. The additional cost required to carry out the objective of price stabilization is then the average variable cost, which can be compared with the estimated benefits of price stabilization. If this view is correct, then the cost of price stabilization would not be as expensive as is normally assumed. This cost issue will be discussed further subsequently.

Price stabilization involves a number of other issues, including, for example, the macroeconomic effect and the effect on risk behavior of farmers. For developing economies, these indirect effects of price stabilization are far more important than the direct effects discussed in this section. The effect of a stable price environment on investment decisions by entrepreneurs and the resulting impact on economic growth are particularly significant. But there are enormous difficulties in the measurement of indirect effects, and the subject has received little attention in empirical research. These issues are, however, beyond the scope of this paper.

This brief exposition of conceptual issues is included here to help explain the complexities of price stabilization in terms that are understandable to policymakers. Obviously, there is considerable room for pragmatism. On this note, the nature and extent of price fluctuations in rice markets will next be examined.

FLUCTUATION IN RICE PRICES

The problem of instability in prices is a source of great concern to farmers and consumers in low-income countries. Low-income consumers are extraordinarily vulnerable to sharp increases in food prices. The lowest 20 percent in the income distribution makes 10 times as much adjustment to increases in foodgrain prices as the top 5 percent (Mellor 1978). Naturally, the starting point of any exercise for stabilizing prices is to probe into the nature and extent of price fluctuation. In this section, the fluctuations in annual and monthly rice prices are examined with particular emphasis on decomposition of nominal prices into trend, seasonal, and irregular components.

Fluctuation of Annual Prices

Fluctuation can be measured in a number of ways. A price change in a given year relative to the price of the preceding year is an often-referred-to measure of nominal fluctuation. Such a measure fails to distinguish between trend and random elements of fluctuation. The trend element can be separated from the random component by a variety of procedures, such as simple linear or log-linear regressions or detrending by a moving-average technique. In this study, a linear regression of annual prices on time gives an extremely poor fit of the trend line, and hence wide fluctuation in the residuals. In Table 3, the fluctuations are measured in reference to the previous year's price, as well as from a log-linear trend and a moving average.

Year-to-year fluctuations of nominal prices were high during 1972-75 (column 2 of Table 3). Excluding the years from 1972 to 1975, the year-to-year fluctuation in nominal prices during 1976-84 ranged from 4 to 41 percent, compared with a range of 1 to 32 percent during 1960-70. Year-to-year nominal fluctuations greater than 10 percent occurred in 7 out of 9 years in the former period, compared with 5 out of 10 years in the latter. Therefore, by this measure, the 1960-70 decade had more price stability than the 1976-84 period.

In order to detrend prices so that fluctuations around the trend can provide a more meaningful measure of variability, two methods are adopted here: a moving average and a log-linear function for trend. A comparison of Figure 6 with Figure 7 clearly indicates that the moving average method provides a better fit. The deviations of actual prices from both these trend estimates are shown in columns 4 and 5 of Table 3. When the trend-cycle element of fluctuation is reduced, the pattern remains similar to year-to-year nominal fluctuation. This is, however, not the case with the log-linear detrending, which, because of its poorer fit, shows more fluctuation during 1960-70 compared with that in 1976-84. Deviations from the moving average indicate that the range of fluctuation in prices was between 1 and 18 percent, plus or minus, during 1976-84, compared with 2 and 13 percent during 1960-70. Figure 7 shows that deviations were slightly more ample during 1976-84 than those in 1960-70.

To demonstrate fluctuation in real prices, it is necessary to deflate nominal prices by some price index. Here the price index of manufactured consumer goods is used for this purpose because the rice weight is very high in the general price index in Bangladesh. The pattern of fluctuation in real prices is shown in Figure 8. Qualitatively,

Table 3—Fluctuation in annual prices of rice, 1960-84

Year	Actual Price	Change from Previous Year	Moving Average Price	Deviation of Actual Price from Moving Average	Deviation of Actual from Log-Linear Trend
	(Tk/maund)	(percent)	(Tk/maund)	(percent)	
1960	24.50	...	...	...	35.0
1961	25.20	3.0	25.60	-2.0	24.0
1962	27.10	8.0	25.50	6.0	18.0
1963	24.20	-11.0	25.30	-4.0	-6.0
1964	24.50	1.0	25.90	-5.0	15.0
1965	29.10	19.0	30.60	-5.0	-11.0
1966	38.40	32.0	34.10	13.0	5.0
1967	34.70	-10.0	37.30	-7.0	-16.0
1968	38.70	12.0	37.60	3.0	-17.0
1969	39.50	2.0	38.50	3.0	-24.0
1970	37.20	-6.0	40.60	-8.0	-37.0
1971	45.20	22.0	51.80	-13.0	-31.0
1972	73.10	62.0	71.99	2.0	-1.0
1973	97.50	33.0	126.00	-23.0	17.0
1974	207.30	113.0	145.60	42.0	121.0
1975	132.10	-36.0	149.80	-12.0	25.0
1976	110.00	-17.0	127.00	-13.0	-7.0
1977	139.00	26.0	131.30	6.0	4.0
1978	144.90	4.0	162.90	-11.0	-3.0
1979	204.70	41.0	172.80	18.0	21.0
1980	168.90	-17.0	196.60	-14.0	-11.0
1981	216.30	28.0	208.30	4.0	1.0
1982	239.60	11.0	237.70	1.0	0.0
1983	257.20	7.0	261.10	-1.0	-5.0
1984	286.47	11.0	...	...	-6.0

Source: Actual nominal prices are from data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

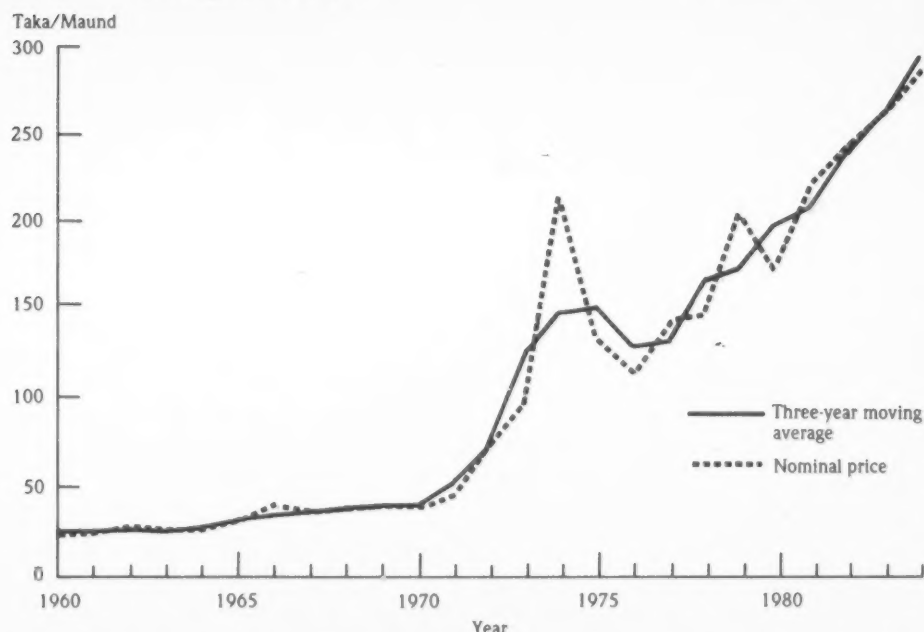
the pattern is not much different from that in the foregoing discussion. However, no price index of manufactured goods is available for the 1960-70 period. Therefore that period is excluded from the conclusions. For the period 1976-83, the index of manufactured goods prices shows a slightly higher rate-of-trend increase than nominal rice prices, thus producing a slightly declining trend of real rice prices. However, the movements of rice and manufactured goods prices are such that the degree of fluctuation in real rice prices is smaller than that of nominal prices.

Fluctuation of Monthly Prices

The fluctuations in monthly prices are examined in two steps. First, the extent and pattern of month-to-month variations in nominal prices are probed. Second, the nominal prices are decomposed into trend, pure seasonal, and irregular components to highlight the contributions of each of the components to the overall fluctuation in nominal prices. This brings out the underlying seasonality in rice prices.

The extent of fluctuations in monthly prices for the 1960s, the 1970s, and the early 1980s is shown in Table 4. Two indicators are presented. The first indicator measures the simple range—that is, the difference between the lowest and highest

Figure 6—Nominal annual rice prices compared with three-year moving averages, 1968-84



Source: Based on data from Bangladesh Bureau of Statistics, *National Report on the 1983/84 Census of Agriculture and Livestock* (Dhaka: BBS, 1986).

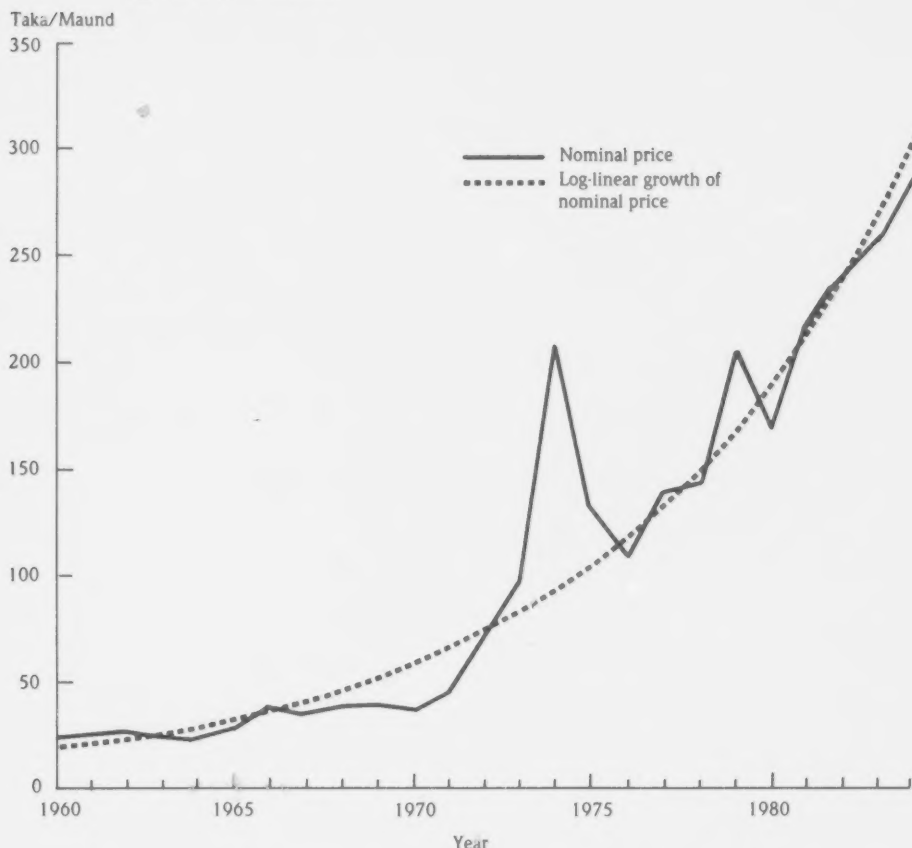
monthly price indexes. The monthly price indexes are based, for every year, on the January price (January equals 100). The second indicator is the coefficient of variation, which is defined as the standard deviation of monthly prices in a year, deflated by the average price. This indicator is more comprehensive than the first and can be interpreted as a measure of fluctuation expressed as a percentage of average price. The following conclusions can be derived from information in Table 4.

1. As indicated by the first indicator, monthly price fluctuations exceeded 35 percentage points in only 2 years out of 10 (that is, once every 5 years) during the period 1960-70. In the period 1971-75, the years of civil war and postwar turmoil and famine in Bangladesh, monthly nominal prices fluctuated more than 35 percentage points in all of these years. During the period 1976-84, fluctuations in monthly nominal prices exceeded 35 points in 2 out of 9 years.

2. December-January, particularly January, is the period when rice prices are low in Bangladesh. Exceptions to this rule have occurred only three times in a period of 24 years. These exceptions can be traced to the beginnings or ends of abnormal price movements and the consequent adjustment process. The low-price period of December-January clearly coincides with the harvest of the main rice crop, the aman rice.

3. Unlike the distribution of low-price points, the high-price points are not distributed so consistently over specific months. High-price points in rice prices generally occurred in the months of July and October-November during the 1960s. During the

Figure 7—Nominal annual rice prices compared with log-linear annual growth, 1968-84

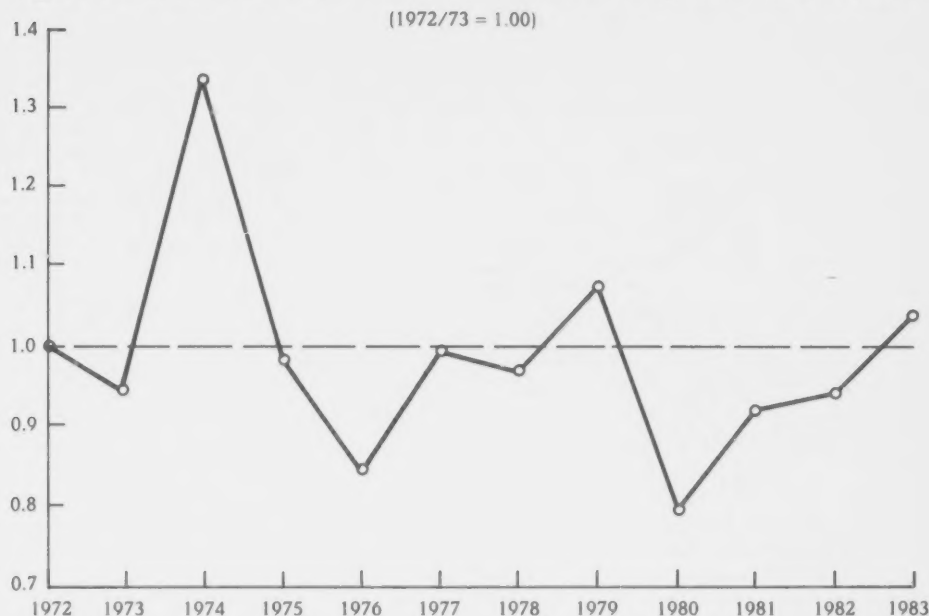


Source: Based on data from Bangladesh Bureau of Statistics, *National Report on the 1983/84 Census of Agriculture and Livestock* (Dhaka: BBS, 1986).

late 1970s and early 1980s, high-price points occurred more frequently in May and August than in other months. The incidence of high prices in October-November thus appears to have diminished in the 1976-84 period compared with 1960-70.

Another way of looking at the variations in monthly nominal prices is to consider prices at particular months over a number of years (say January prices of 1960-70) and to measure the coefficient of variation around a simple time trend (Table 5). The statistics in Table 5 indicate that the extent of variation in monthly prices was higher in 1971-75 compared with either 1960-70 or 1976-84. The early years show a relatively constant coefficient of variation across months, whereas the latter two periods exhibit a wide range from month to month. For 1976-84 the high coefficients from July to October raise a question as to whether production with new technology, most of which is harvested during July to October, has caused this phenomenon. In general, there has been little change from the 1960s to the recent period.

Figure 8—Ratio of the rice index to the manufactured goods index, 1972-83



Source: Computed from Bangladesh Bureau of Statistics, *Statistical Yearbook 1985/86* (Dhaka: BBS, 1986).

Decomposition of Nominal Prices

There are numerous methods for seasonally adjusting economic time series, all of which are based on the premise that seasonal fluctuations can be measured in an original nominal series and separated from trend, cyclical, and irregular fluctuations. The seasonal component is defined as the intrayear pattern of variation, which is repeated constantly or evolves from year to year. The trend-cycle component includes the long-term trend and business cycle, if any. The irregular component is composed of residual variations, such as the sudden impact of political events, the effect of abnormal weather conditions, and reporting and sampling errors. The series adjusted for the seasonality factor consists of trend-cycle and irregular components. Similarly, the series adjusted for trend-cycle and irregular factors consists of the pure seasonal component.

The method for decomposition of the original price series into trend-cycle, seasonal, and irregular factors in this study is based on the X-11 procedure developed by the U.S. Bureau of the Census for adjusting economic series for seasonality (U.S. Department of Commerce 1976). Among the various approaches considered, the X-11 proved the most flexible and appropriate for this price series. The procedure has the advantage of relatively precise measurements of the components and enormous flexibility in application for various types of time series. A brief description of the technical ingredients of the X-11 procedure is presented in Appendix 1 of this study.

In summary, the moving-average technique is the central element of the procedure, and iterative steps of moving averages are constructed to arrive at final results. A choice

Table 4—Extent of fluctuation in monthly nominal prices of rice, 1960-84

Year	Fluctuation ^a	Coefficient of Variation ^b	Month of Lowest Price Point	Month of Highest Price Point
	(percent)			
1960	39.9	0.113	January	July
1961	23.4	0.055	January	November
1962	19.3	0.062	January	July
1963	16.4	0.054	December	July
1964	23.9	0.073	April	October
1965	30.3	0.087	January	October
1966	58.9	0.167	January	October
1967	20.4	0.062	January	July
1968	31.3	0.105	February	November
1969	26.7	0.073	January	October
1970	21.4	0.074	December	July
1971	36.3	0.102	January	November
1972	84.0	0.213	January	October
1973	44.7	0.108	January	June
1974	154.5	0.362	January	October
1975	84.0	0.244	December	April
1976	10.8	0.033	July	February
1977	52.9	0.138	January	August
1978	17.6	0.046	January	May
1979	70.4	0.191	January	August
1980	22.9	0.093	December	May
1981	33.9	0.088	January	December
1982	29.2	0.107	January	May
1983	19.2	0.048	January	November
1984	26.7	0.071	January	October

Source: Computed from price data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

^a Price fluctuation is measured as the difference between the highest and lowest index numbers; the index number of a month is based on the January price as 100 and constructed separately for months in a year.

^b The coefficient of variation is the standard deviation divided by the mean.

Table 5—Coefficients of variation of monthly rice prices in 1960-70, 1971-75, and 1976-84

Month	Coefficient of Variation		
	1960-70	1971-75	1976-84
January	0.104	0.429	0.089
February	0.133	0.464	0.100
March	0.134	0.487	0.107
April	0.149	0.450	0.098
May	0.142	0.310	0.108
June	0.139	0.208	0.068
July	0.125	0.205	0.131
August	0.124	0.219	0.162
September	0.102	0.251	0.155
October	0.106	0.352	0.141
November	0.103	0.525	0.105
December	0.101	0.481	0.100

Source: Computed from price data in Table 4, which were provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

Note: The coefficients of variation are computed around a simple time trend.

of several moving averages is available in X-11 for estimating the trend-cycle component. The selection of the appropriate moving average for estimating the trend-cycle component is made on the basis of a preliminary analysis of the data, using the technique provided in the X-11 procedure. The extreme values of irregular components thus derived are replaced by neighboring values if the irregular values fall beyond 2.5σ (two standard deviations). Because of this smoothing adjustment in extreme values, the procedure may underestimate the irregular component, but it produces a consistent picture of seasonality.

Trend Cycle

When nominal prices are decomposed into trend, seasonal, and irregular components, the trend component of rice price is nonlinear and inclusive of cyclical elements. The trend price of rice was reasonably stable during the 1960s (1960-70), but rose sharply during the 1970s and early 1980s (1971-84), with occasional upward bursts in cyclical fashion. Even eliminating the cyclic component, the pure trend is not linear, but closely resembles an exponential growth curve and is consistent with the trend of inflation.

Seasonal Factors

The purely seasonal factors in rice prices are shown in Tables 6 and 7 and Figure 9. The following conclusions emerge clearly from the tables and graphs.

First, comparing 1960-70 and 1976-84 in Figure 9, it can be seen that in the first period the band of seasonality (breadth of the lowest and highest seasonality factors)

Table 6—Index of pure seasonality in monthly rice prices, 1960-84

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1960	90.7	93.9	95.1	98.7	101.5	104.7	107.8	104.5	100.6	100.4	102.9	99.2
1961	90.9	93.9	95.1	98.6	101.3	104.5	107.7	104.3	100.9	100.8	103.1	99.3
1962	91.2	93.5	95.2	98.3	101.3	103.8	107.2	104.2	101.7	101.7	103.5	99.7
1963	91.3	92.7	95.2	97.8	101.1	103.1	106.7	104.3	102.5	102.8	104.0	99.7
1964	91.1	91.9	95.4	97.5	100.8	102.5	106.2	104.7	102.9	104.0	104.5	99.9
1965	90.4	91.3	95.4	97.1	100.5	102.2	106.1	105.5	103.1	104.7	104.9	99.7
1966	89.5	90.9	95.4	97.0	100.6	102.2	106.2	106.0	102.9	105.3	105.2	99.5
1967	88.5	90.5	95.0	97.3	101.0	102.7	106.7	106.5	102.4	105.3	105.2	99.0
1968	87.8	90.4	94.4	97.8	101.9	103.8	106.9	106.4	101.5	105.1	105.2	98.6
1969	87.4	90.2	93.6	98.5	103.0	105.0	107.1	105.9	100.9	104.8	104.9	97.8
1970	87.2	90.2	93.1	99.2	104.6	106.3	106.9	104.7	100.5	104.6	104.7	97.0
1971	87.2	90.1	92.7	100.3	106.2	107.0	106.2	103.9	100.3	104.6	104.3	95.9
1972	87.3	90.2	93.3	100.9	107.7	107.4	104.9	103.2	100.1	104.7	103.7	95.1
1973	87.7	90.3	94.4	101.5	108.5	107.0	103.6	103.0	100.1	104.6	103.1	94.7
1974	88.2	90.6	96.1	101.7	108.8	106.1	102.7	103.1	100.3	104.4	102.6	94.6
1975	88.6	91.0	97.2	101.9	108.7	104.9	102.1	103.6	100.5	104.2	102.3	94.6
1976	89.1	91.5	97.8	101.6	108.3	103.9	101.9	104.0	100.8	103.7	102.1	94.5
1977	89.5	92.4	98.0	101.6	108.0	103.4	102.0	103.6	101.0	103.2	101.8	94.8
1978	89.9	93.3	98.1	101.8	108.1	103.3	101.9	102.9	100.5	102.3	101.6	94.9
1979	90.2	94.4	98.7	102.8	108.5	103.4	101.1	101.2	99.2	101.6	101.6	95.5
1980	90.8	95.5	99.9	104.0	108.7	103.6	99.8	99.4	97.6	101.1	101.6	95.8
1981	91.6	96.9	101.3	105.4	108.6	103.5	98.3	97.7	95.9	100.9	101.7	96.6
1982	92.4	98.1	102.4	106.4	108.2	103.1	97.0	96.7	94.7	100.9	102.0	97.4
1983	93.0	98.9	103.0	107.1	107.6	102.6	96.1	96.1	93.9	101.3	102.2	98.1
1984	93.3	99.2	103.2	107.4	107.2	102.3	95.6	95.8	93.6	101.7	102.5	98.1

Note: The procedure for computing the index is described in Appendix 1.

Table 7—Dispersion of the index of pure seasonality in rice prices, with low and high price months, 1960-84

Year	Range	Minimum	Maximum	Low Month	High Month
1960	17.14	90.68	107.82	January	July
1961	16.76	90.89	107.65	January	July
1962	16.00	91.17	107.17	January	July
1963	15.40	91.28	106.68	January	July
1964	15.12	91.07	106.19	January	July
1965	15.71	90.42	106.13	January	July
1966	16.76	89.46	106.22	January	July
1967	18.11	88.55	106.66	January	July
1968	19.12	87.79	106.91	January	July
1969	19.75	87.40	106.91	January	July
1970	19.66	87.19	106.85	January	July
1971	19.85	87.19	107.04	January	June
1972	20.38	87.28	107.66	January	May
1973	20.77	87.71	108.48	January	May
1974	20.59	88.17	108.76	January	May
1975	20.01	88.65	108.66	January	May
1976	19.18	89.14	108.32	January	May
1977	18.53	89.49	108.02	January	May
1978	18.20	89.85	108.05	January	May
1979	18.29	90.23	108.52	January	May
1980	17.88	90.81	108.69	January	May
1981	17.02	91.55	108.57	January	May
1982	15.73	92.44	108.17	January	May
1983	14.63	93.01	107.64	January	May
1984	14.12	93.29	107.41	January	April

Source: This index is based on the seasonality index in Table 6.

gradually widened. The opposite pattern (a gradual narrowing) can be discerned in the latter period (1976-84). However, the downward fluctuations were increasingly smaller during 1976-84 compared with the first period. The difference in upward fluctuation between the two periods is not so sharp.

Second, as far as the seasonality factor is concerned, the lowest factor price has occurred in the month of January in all periods, although a new strong second low is evident in the 1976-84 years. The highest seasonal price was always in July during the first period, but it moved back to April and May in the later years.

A dramatic overall change in the pattern of price seasonality occurred over the 24-year period from 1960-84. This movement is best brought out by comparing the average seasonality factors of the first three years, 1960-62, with those of the last three, 1982-84 (Figure 10). The large shifts in the shares of the three rice crops due to the advent of HYVs are visibly reflected in the patterns of seasonality factors in the two periods. In the earlier period, prices started at their lowest in January (the aman season) and rose steadily through July, before retreating with the arrival of the smaller aus and boro crops in August and September.

In recent years, the lowest month has still been January (aman), but the earlier and larger arrivals of aus and boro rice during June-August have caused prices to drop close to their January levels. The direct result for any price stabilization scheme is that careful attention must be paid to both harvest seasons. In addition, the shifts of seasonality are ongoing and require periodic reassessment for policymakers to keep up with their evolution.

Figure 9—Seasonal index, 1960-70 and 1976-84

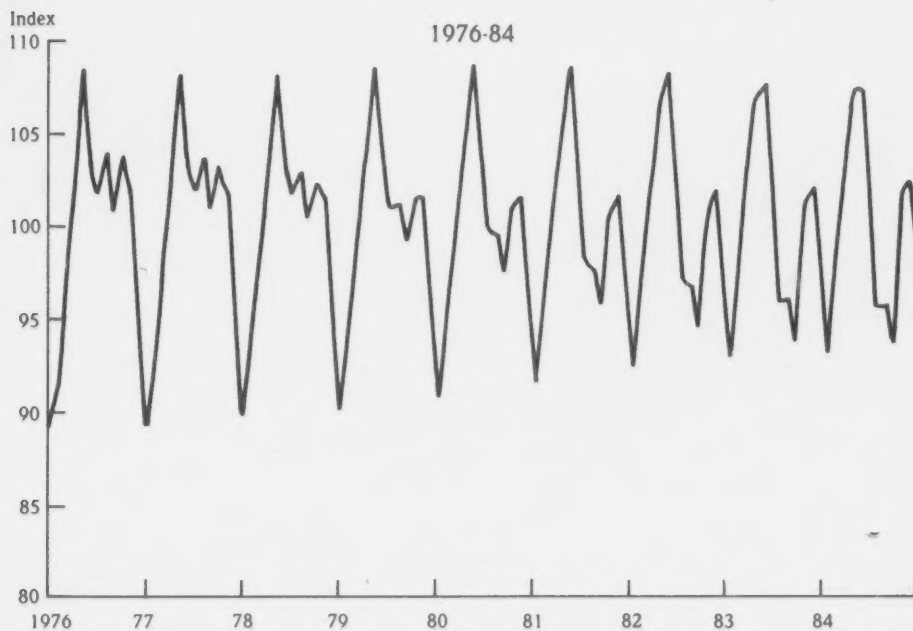
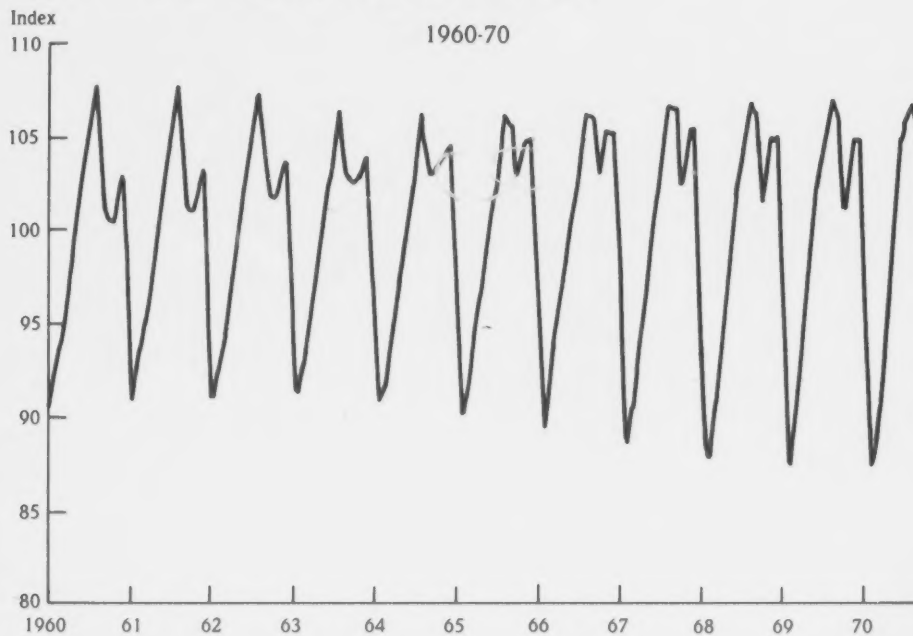
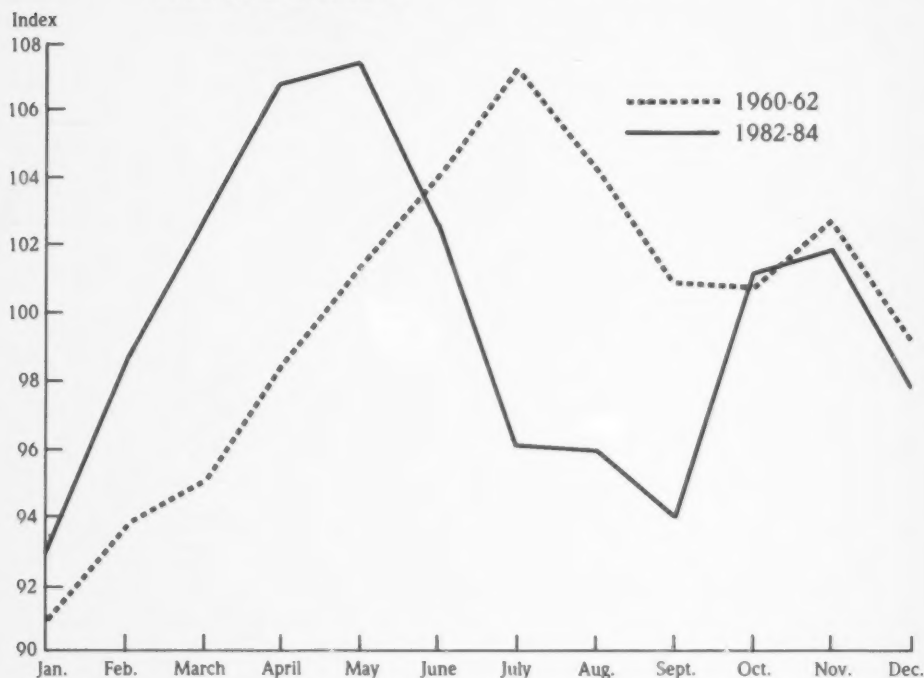


Figure 10—Seasonal factors in rice prices based on three-year averages, 1960-62 and 1982-84



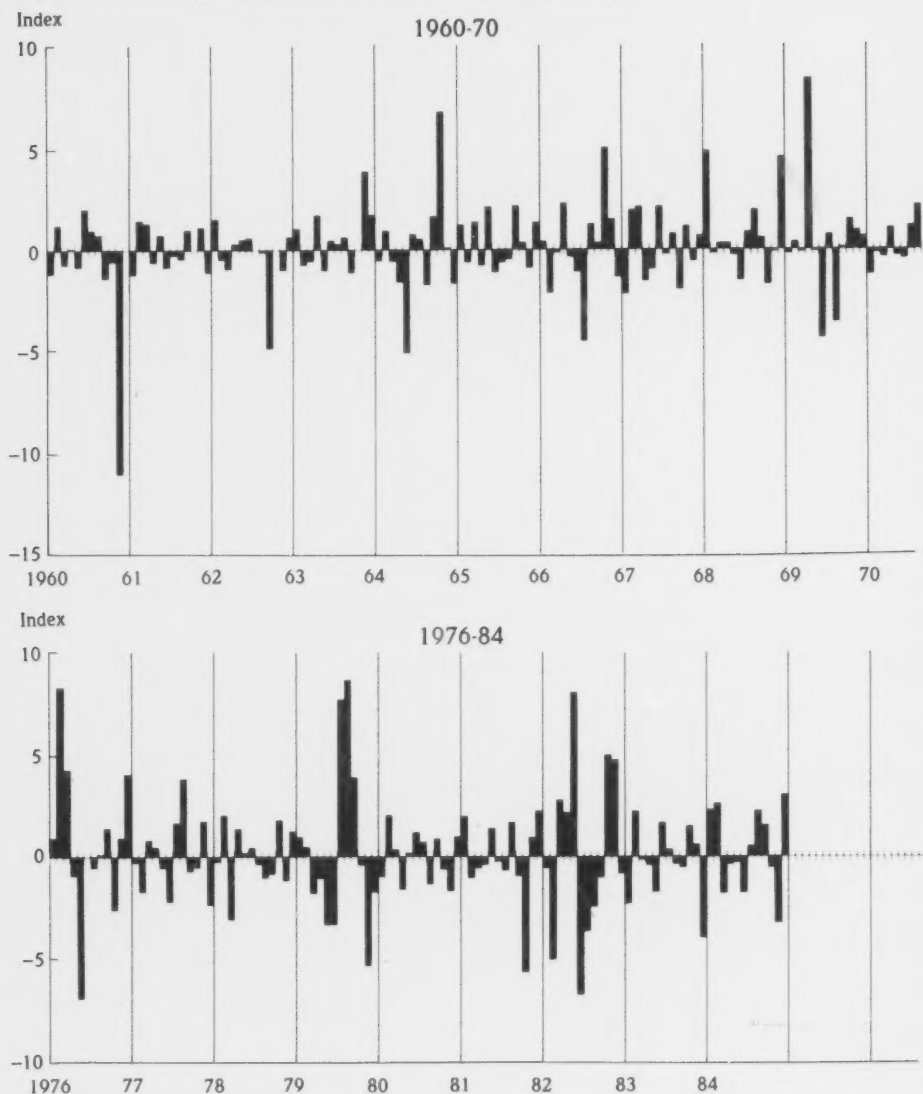
Irregular Factors

Irregular factors represent random effects on prices, generally arising from weather variations but not exclusive of other random phenomena like availability of food aid, war, or erratic public actions. The measurements of irregular factors in the monthly rice prices during 1960-70 and 1976-84 are shown in Figure 11. Comparison of these figures clearly demonstrates that the frequencies as well as amplitudes of irregular factors were much larger during the period 1971-75 relative to either 1960-70 or 1976-84. However, the differences between 1960-70 and 1976-84, the periods of particular interest, are not so obvious. In terms of the number of times when positive or negative deviations of irregular factors exceeded five points, the period 1976-84 appears to be somewhat more volatile than 1960-70. During 1960-70 such deviations occurred in 4 out of 10 years (0.40 per year) compared with 7 in 9 years (0.78 per year) during 1976-84. The 1960s appear to have been relatively blessed compared with either the 1970s or early 1980s.

Integration of Factors

Once the nominal prices have been decomposed into trend, seasonal, and irregular factors, it should be obvious that these can also be integrated to result in the nominal price. This procedure is simple. Trend factors are measured in taka per unit (maund) of rice, whereas seasonal and irregular factors are index numbers based at 100. A multiplicative relation produces this integration as shown in equation (1).

Figure 11—Irregular factors, 1960-70 and 1976-84



Note: The procedure for computing the index is described in Appendix 1.

$$\text{NP} = \text{TR} \cdot \text{SF} \cdot \text{IF}, \quad (1)$$

where

NP = nominal price,
 TR = trend factor,
 SF = seasonal factor, and
 IF = irregular factor.

(See Appendix 2, Table 22, for estimates of these components in 1960 and 1984.)

Perhaps it is appropriate to point out that the pure seasonality pattern as shown earlier is somewhat different from the pattern obtained with the nominal prices. The overall difference, as indicated by the pattern of rising and falling phases of prices, is not, however, so significant as the difference at particular months or phases.

Contribution of Components to Variance in Nominal Prices

The variance and the share contributed by each component—trend, seasonal, and irregular factors—will differ depending on whether one takes the monthly prices, the average of a number of months, or the annual average price. The span of months is therefore a critical factor determining the contribution of the components to the total variance in original data. The shares are presented in Table 8 by time spans in months.

It is clear from the table that in monthly price variations in the original series, the seasonal irregular factors play the dominant role. In the 1960-70 series, the contributions of trend, seasonal, and irregular components to variance of monthly prices are 15, 60, and 23 percent, respectively. These shares in trimonthly prices for the same series are 32, 61, and 7 percent. With the 1976-84 series, the shares of trend, seasonal, and irregular components to variance of monthly prices are 21, 52, and 28 percent. For trimonthly (quarterly) prices these shares change to 47, 44, and 9 percent, respectively, for the 1976-84 series. The significant difference between the two series is reflected in the contribution of the trend-cycle factor in monthly and trimonthly price variations.

Table 8—Relative contribution of components of variance in original series, 1960-70 and 1976-84

Period/ Span in Months	Trend Cycle	Seasonal	Irregular
		(percent)	
1960-70			
1	15.05	59.56	23.39
2	22.53	67.00	10.47
3	31.49	61.31	7.20
4	36.19	59.61	4.20
5	40.53	55.42	4.05
6	46.32	50.74	2.93
7	53.44	44.08	2.48
9	70.06	27.08	2.86
11	90.87	7.15	1.98
12	97.18	0.06	2.76
1976-84			
1	20.49	52.01	27.50
2	33.66	48.24	18.11
3	46.87	43.91	9.22
4	60.02	33.84	6.14
5	70.61	23.84	5.56
6	77.35	18.72	3.94
7	81.32	15.40	3.27
9	85.31	12.06	2.64
11	95.12	3.12	1.76
12	97.40	0.12	2.50

Source: This table is computed from the decomposition analysis of prices discussed in Appendix 1.

The share of the trend-cycle factor in these variations is significantly higher in the 1976-84 series compared with the 1960-70 series. Obviously, the differences in inflationary forces between the two periods resulted in this increased share of the trend factor.

It may be concluded from this analysis that the fluctuations in nominal prices that are observed in contemporary rice markets of Bangladesh are the products of factors reflecting trend and cyclical influences, pure seasonal phenomena, and irregular forces. The pure seasonal factors have changed dramatically with the shift of the peak price month from July in the 1960s to May in the 1980s. Although January remains the lowest price month, a new, second low-price period during August-September has emerged in the posttechnology period (1976-84). This change in pure seasonal factors is frequently masked by the trend and irregular factors that influence nominal prices. The inflationary trend factor together with the irregular factors accentuated the fluctuations in nominal prices during 1976-84 compared with 1960-70. On the other hand, the pure seasonality factors contributed to more stability in prices during the latter period. A cyclical rise and fall in rice prices about every other year became the pattern of the trend-cycle component during 1976-84, whereas there was almost no cyclical movement during 1960-70.

CAUSES OF FLUCTUATIONS IN ANNUAL AND SEASONAL PRICES

The price of rice, like that of any other commodity at a given time and a given market, is determined by the interaction of forces of supply and demand, and the expectations of market actors concerning future prices. The question of time is taken into account by analyzing fluctuations of both annual and seasonal prices. Because there are many markets and because aggregate prices are considered here, it is important to determine whether markets are integrated. This is covered in the next section. Changes in expectations and their effects on price fluctuations are not analyzed in this report (see Ravallion 1985 for such an analysis).

Decomposition Analysis of Annual Price Fluctuations

Domestic production and imports exert supply-side influences, and domestic demand and exports constitute demand-side influences on the price of rice. Foodgrains have rarely been exported from Bangladesh, so domestic consumption is the only demand force. If supply and demand move in the same direction in any year, rice prices will tend to stabilize. If supply and demand move in opposite directions in a given year, rice prices will tend to destabilize. The nature of the interaction of supply and demand forces is therefore considered critical in determining price fluctuations. The Bangladesh economy of the early and mid-1960s was mainly agricultural; the share of agriculture in gross domestic product (GDP) was about 70 percent. The urban population was only about 5 percent of the total. Agricultural income largely represented the basis for demand, and agricultural production largely represented supply. An economic structure of this type implies that supply and demand are jointly determined and move in the same direction, resulting in increased price stability. However, by the early 1980s the supply and demand forces had become more independent. Agriculture contributed only 48.5 percent to total GDP; urban and rural nonfarm populations had increased to more than one-fourth of the total population. These structural changes may have contributed to increased price instability, while government policies on foodgrain imports may have mitigated any deleterious effects from the separation of demand and supply. To examine these hypotheses, the following formal model is used.

The Model

The methodology in this exercise uses a simple supply and demand equilibrium model to decompose price variance. The formal version is as follows:

$$Q_d = a - bP_t, \quad (2)$$

$$Q_s = c + dP_t, \quad (3)$$

$$Q_i = e, \text{ and} \quad (4)$$

$$Q_d = Q_s + Q_i, \quad (5)$$

where a is the demand intercept, c is the supply intercept, e is the import intercept, and b and d are the slope parameters. Imports are determined independently of domestic price, so equation (4) has no slope parameters. Attempts to fit an equation of imports on domestic and world prices show no significant relations. Whereas policy may use an expected price in deciding about imports, delays in arrivals or other aid-related factors obscure relations in past data. It should be noted here that while many exogenous factors (income, wealth, and so forth) influence prices and quantities in this system, the model conveniently reduces them to net intercept terms in order to greatly reduce data and computational needs. Given the objectives of examining the effect on price variance of broad forces of supply and demand, such a simplified model is appropriate.

This structural model, which was employed first by Piggot (1978, 1986), is then loosened somewhat by equating the slope parameters with the elasticities evaluated at the means (following Myers and Runge 1985), resulting in

$$b = \varepsilon_d \cdot (q/p), \text{ and} \quad (6)$$

$$d = \varepsilon_s \cdot (q/p), \quad (7)$$

where ε_d is the elasticity of demand and ε_s is the elasticity of supply.

The constants are finally derived as

$$a = Q_d + bPt, \quad (8)$$

$$c = Q_s - dPt, \text{ and} \quad (9)$$

$$e = Qi. \quad (10)$$

In matrix notation the system of equations (2) through (5) can be written:

$$AY = C, \quad (11)$$

where A is a matrix of coefficients associated with the endogenous variables (price and quantity), Y is a matrix of endogenous variables, and C is a matrix of net intercepts.

The variance-covariance matrix of the endogenous variables is

$$T = xv'x', \quad (12)$$

where

T = the desired variance-covariance matrix,

$x = A^{-1}$,

v = the variance-covariance matrix of the net intercepts, and

x' = the inverse of x .

From this form the composite elements of variance directly attributable to demand, supply, and import intercepts and their interactions can be easily identified. The contributions of demand for and imports of domestic products and their interactions with the variance of prices are measured for the 1961-70 and 1975-84 periods. The price elasticity of demand is assumed to be -0.4 , and the price elasticity of supply is allowed to vary from 0.2 to 0.4 , particularly to accommodate the situation in the second period. Most cross-section and time series estimates of price elasticity of demand center around -0.4 (Ahmed 1981, Pitt 1983).

Results

The contributions to the total price variance of the six components—demand, production, imports, interaction of demand and production, interaction of demand and imports, and interaction of production and imports—are shown in Table 9. These contributions change dramatically between the first and second time periods. The first decade is characterized by large, positive, direct effects of domestic production and demand and a comparably large, negative interaction term. Over the range of results, imports play a small role. As Myers and Runge (1985) found in their analysis of the U.S. maize market, this large interaction term is the result of the simultaneous shifting

Table 9—Decomposition of price variability, 1961-70 and 1974-83

Variable	Percent of Price Variance Explained		Ratio of Demand/Net Supply Effects	
	1961-70	1974-83	1961-70	1974-83
	(percent)			
$\epsilon_s = 0.20$				
Demand	305	60	1.05	1.17
Demand/supply interaction	-486	35		
Demand/import interaction	-1	-35		
Supply	289	44		
Supply/import interaction	-9	-10		
Imports	2	7		
Total	100	100		
$\epsilon_s = 0.25$				
Demand	261	51	1.02	0.98
Demand/supply interaction	-406	38		
Demand/import interaction	-1	-30		
Supply	253	46		
Supply/import interaction	-8	-11		
Imports	2	6		
Total	100	100		
$\epsilon_s = 0.30$				
Demand	225	45	0.99	0.85
Demand/supply interaction	-343	40		
Demand/import interaction	-1	-26		
Supply	225	48		
Supply/import interaction	-8	-11		
Imports	2	5		
Total	100	100		
$\epsilon_s = 0.35$				
Demand	196	39	0.96	0.74
Demand/supply interaction	-293	41		
Demand/import interaction	-1	-23		
Supply	203	49		
Supply/import interaction	-7	-11		
Imports	2	4		
Total	100	100		
$\epsilon_s = 0.40$				
Demand	173	35	0.93	0.64
Demand/supply interaction	-252	42		
Demand/import interaction	-1	-20		
Supply	185	51		
Supply/import interaction	-6	-12		
Imports	1	4		
Total	100	100		

Note: Numbers may not add to total because of rounding. The demand elasticity is $\epsilon_d = -0.4$, and the supply elasticities (ϵ_s) are given in the table.

of supply and demand curves, hypothesized earlier in this section. This study suggests that the shifts are outward movements of both curves.

The characteristics of the second time period are quite different. The direct demand and domestic production components are remarkably smaller, and more important, their interaction terms have switched signs. No longer are the curves shifting in the same direction, and no longer is the price being stabilized by the interaction of supply and demand. The hypothesis that supply and demand forces have become more independent in the second time period is reinforced by these results.

The effect of imports has increased strongly in the later decade. The demand-import covariances are always negative, as are those of domestic production and imports, and they largely offset the positive production-demand covariances. Thus a fundamental shift in the overall structure of price variability has occurred between the two periods. In the latter time period, at almost every level of supply elasticity, the contribution of supply variability to price variability is higher than that of demand. More important, if the supply elasticity increases between periods (as is hypothesized for the advent of the new rice technology), then the shift is more dramatic. During the 1960s the contributions of supply and demand forces were almost equal to price variation. In the late 1970s and early 1980s supply variability became the dominant force behind price fluctuations.

Even though changes in supply elasticity make a difference in the results, they do not influence the conclusions concerning imports. At all levels of elasticity, imports became more important in overall price variance in the second period. Especially noteworthy are the large negative covariances: imports helped to offset shortfalls in supply and increases in demand.

The foregoing conclusions are important to the analysis of contemporary policies in price stabilization. In attempting to derive lessons for current policy purposes, a straightforward comparison of policies in the 1960s and those practiced now may be hazardous unless this structural change in demand-supply relations is kept in view. On the domestic front, the major sources of price instability are the weather factors that affect production. Forecasting domestic production under the influence of randomly occurring weather disturbances has assumed an added importance in a structural situation where demand and supply forces are becoming more and more independent. In this context, a brief analysis of the effects of flood and drought on variability of production is quite revealing.

Random Effects of Flood and Drought

Earlier it was shown that extremely irregular fluctuations in prices were more frequent in 1976-84 than in 1960-70. Government efforts to stabilize prices were more intensive in the later than in the earlier period. During 1976-84, domestic procurement of foodgrains as a price support measure reached half a million tons (equivalent to 25 to 40 percent of marketed surplus) in good production years. Open market sales from public stock during poor harvest years were also introduced during this period. Neither procurement for price support nor open market sales were effectively employed to stabilize prices in 1960-70. However, erratic behavior of public purchases, imports, and sales may aggravate rather than pacify instability in prices. This happens primarily because of the misreading of the effects of natural calamity when the government responds vigorously to counteract the effects of floods, droughts, and cyclones with excessive or inadequate imports of foodgrains.

An accurate assessment of crop damages from natural disasters is therefore crucial

for combating erratic movements in foodgrain prices. The government has an established procedure and mechanism for assessing crop damages from natural calamities.² Table 10 gives a picture of the size of the loss in production of rice crops due to flood and cyclone. Although these statistics are less reliable than crop production estimates, the relative intensity of the adverse effects of flood and cyclone in various years is reflected. The estimates of crop loss from drought are not available. It is difficult to assess loss from drought because such damages are often intricately enmeshed with land productivity and various factors that influence this productivity. Unlike flood damage, drought loss cannot be easily identified and measured, except when farmers fail to sow or plant because of drought. Nevertheless, loss from drought is likely to be more severe than that from flood in Bangladesh.

The data in Table 10 show that flood damage is more frequent than cyclone damage, and aus and aman rice crops are more vulnerable to flood than boro. However, as more areas are sown with HYVs, the proportion of HYV crop loss due to flood appears to be larger than the overall proportion of HYVs in total rice-cropped area. While the share of HYVs in total rice-cropped area ranged from 19 to 24 percent during 1979/80-1983/84, the share of the HYV crop lost to flood appears to range from 31 to 50 percent of total rice losses in the same period. The capacity of HYVs to overcome short-duration flooding and drought is generally much weaker than that of local varieties. The interaction of HYVs and natural calamity thus increases instability in production and prices. The estimates of loss of production from flooding, as presented in Table 10, are in

Table 10—Loss of rice production from floods and cyclones, 1969-84

Calendar Year	Total Loss	Share of Aus in Total Loss	Share of Aman in Total Loss	Share of Boro in Total Loss	Share of HYVs in Total Loss	Share Lost from Floods	Share Lost from Cyclones
	(1,000 metric tons)				(percent)		
1969	218.08	15.2	83.7	1.1	0.9	100.0	0.0
1970	1,411.95	13.8	86.0	0.1	0.1	47.1	52.9
1971	305.27	18.0	82.0	0.0	6.0	100.0	0.0
1972	244.82	30.0	70.0	0.0	0.2	100.0	0.0
1973	895.15	22.2	77.8	0.0	13.0	67.8	32.2
1974	535.41	43.5	56.5	0.0	13.3	100.0	0.0
1975	279.57	24.2	9.0	66.8	25.6	100.0	0.0
1976	681.85	51.5	38.7	9.8	31.7	100.0	0.0
1977	402.33	3.6	14.3	82.1	27.5	17.8	82.2
1978	131.12	49.7	24.6	25.7	39.8	99.7	0.3
1979	60.47	22.3	77.7	0.0	12.2	100.0	0.0
1980	285.05	10.4	88.1	1.5	40.5	100.0	0.0
1981	158.90	33.8	13.0	53.2	47.3	100.0	0.0
1982	175.22	25.2	53.8	21.0	42.2	100.0	0.0
1983	540.15	28.1	45.9	25.0	50.3	100.0	0.0
1984	1,949.17	16.2	4.7	19.1	30.5	100.0	0.0

Sources: Computed from Bangladesh, Bureau of Statistics, *Agricultural Yearbook 1979-80* (Dhaka: BBS, 1981); and Bangladesh, Bureau of Statistics, *Statistical Yearbook of Bangladesh, 1985* (Dhaka: BBS, 1986).

² In the event of a natural calamity, the government's agriculture extension workers and statistical assistants at the *upazila* and *union* administrative levels are asked to assess the extent of damages in planted areas and yields of various crops in the afflicted zones. This information is examined and aggregated at various levels before final aggregation at the national levels.

calendar years. These estimates are rearranged into fiscal years to compare them with the annual official statistics of rice production, which are available in fiscal years in Table 11. Some interesting lessons on relative adverse effects of flooding and droughts clearly emerge from this data. First, in almost all years with moderate to severe flooding (crop loss of more than 300,000 tons)³ but with no severe drought, actual production of rice has remained above trend production. This supports the hypothesis that location-specific flood losses do not lead to an aggregate loss of crop production by the same amount. Flooding causes locational income and employment problems, but it does not adversely affect, and may even improve aggregate supply and hence average prices.⁴ Flooding is caused by excessive rainfall, which may cause crop damage in low-lying areas but at the same time improves soil moisture and crop yields in highland rice crops. In most flood years, the average actual yields are higher than trend yields. Montgomery (1985) arrived at similar conclusions in his analysis of the effects of flooding in Bangladesh.

Second, the impact on aggregate production becomes most serious when severe floods and droughts occur in the same year. Third, a severe drought, even without a severe or moderate flood, is often found to cause actual aggregate production to fall below trend production. Thus, drought is more menacing than flood in Bangladesh as far as aggregate production is concerned.

Causal Analysis of Seasonal Price Fluctuations

In analyzing the factors that explain the pattern of seasonality in prices, particular emphasis is placed on new technology and on storage costs.

Storage Costs and Seasonal Prices

If traders in a competitive market always knew in advance what the peak price would be in the upcoming season, and if they did not have any capital constraint, then they would purchase and store as much rice in the harvest season as they would be able to sell in the peak price season to maximize total profit. This would be possible only if the storage cost, including a normal profit, is accommodated within the price gap between harvest and peak seasons. In this situation the seasonal factor—that is, the price spread between the two seasons—would be equal to the storage cost. But the reality will certainly be different. The peak price cannot be foreseen with certainty; only a speculative guess based on current information is possible. The market may not be competitive, particularly if capital is constrained. Therefore, in any particular trading period, seasonal price spreads are likely to deviate from the storage cost. But over a number of trading periods, the average price spread would tend to be equal to the storage cost, implying that excess profits in some periods compensate for losses in others.

In the context of developing market economies, the storage cost is something that cannot be identified with the prevailing interest rates in the organized financial markets. In such countries the storage function is performed by farmers, full-time traders, and government. Farmers in Bangladesh store about a quarter of the marketable surplus of rice, although precise estimates are hard to find (Bangladesh, Bureau of Statistics 1968).

³ All tons in this report are metric tons.

⁴ The classic case was the 1976/77 cyclone and flood damage, which was largely limited to the district of Sylhet, where the government had to take special measures to support income and employment of the poor even though the national average price in that year was lower than the previous year.

Table 11—Relative adverse effects of flood and drought on production of rice, 1969/70 to 1983/84

Fiscal Years ^a	Flood Loss	Deviation of Production from Trend	Deviation of Yield Rate from Trend	Deviation of Area Planted from Trend	Recorded Drought Status
	(1,000 metric tons)		(ton/acre)	(1,000 acres)	
1969/70	218.14	1,488.60	0.0313	1,531.73	...
1970/71	1,409.58	375.40	0.0070	402.99	...
1971/72 ^b	305.27	-1,082.80	-0.0218	-1,302.75	...
1972/73	244.82	-1,191.00	-0.0388	-568.50	Severe
1973/74	895.15	333.80	0.0161	-91.24	...
1974/75	722.26	-543.40	-0.0129	440.98	Severe
1975/76	159.63	643.40	0.0121	750.28	...
1976/77	945.58	-615.80	-0.0142	-492.47	Moderate
1977/78	109.54	316.00	0.0193	-270.21	...
1978/79	97.45	-67.20	0.0021	-192.95	...
1979/80	64.60	-439.40	-0.0123	-215.70	Severe
1980/81	365.44	419.40	0.0166	16.56	...
1981/82	95.37	-93.80	-0.0086	250.82	Severe
1982/83	180.11	217.00	-0.0007	427.07	...
1983/84	590.02	239.80	0.0043	195.33	...

Sources: Computed from flood loss statistics in Bangladesh, Bureau of Statistics, *Statistical Yearbook* (Dhaka: BBS, 1986) and Bangladesh, Bureau of Statistics, *Agricultural Yearbook 1979/80* (Dhaka: BBS, 1981).

^a When crop losses are rearranged from crop years to fiscal years, the following adjustments are made: the figures for aus and aman rice in crop year 1969 and those for boro in crop year 1970 constitute the total for the fiscal year 1969/70.

^b This is the year of civil war in Bangladesh when about 3 million people died, resulting in large-scale failure to plant or sow rice crops.

The storage cost and possible benefit at the farm level is dependent on a host of factors including conditions in the informal credit market and food security considerations. The informal credit market is highly fragmented and restricted in scope, and the implicit interest rate in these markets is often quite high. An interest rate in excess of 50 percent per year is not uncommon. But this does not mean that everybody can lend money at that rate. In fact, a large majority of farmers with surplus financial resources cannot find opportunities for investment in informal credit markets. Therefore, the market is limited to friends and relatives and to those who can ensure a credit discipline and loan security of various forms (such as a land mortgage or sales contract for commodities or assets). Some farmers also hold stock for reasons of food security. They delay sale of surplus stock from the current harvest until it becomes clear that the next harvest is going to provide an adequate supply for the next consumption period. Of course, distress sales occasionally override this food security consideration, but such sales are generally a small fraction of total sales.⁵

Theoretically, organized commercial banks in rural areas can provide an alternative opportunity to surplus farmers for investment, and the interest rate in these banks can serve as a basis for estimating the storage cost of farm stockholders. In fact, establishment of commercial banking has progressed in Bangladesh so that almost all *upazilas* (administrative units of about 100 villages) do have a bank. But corruption, illiteracy, lack of

⁵ Part of the distress sale figure may also be the result of inadequate physical storage facilities on farms, particularly among small farmers with poor housing.

banking tradition, and interest rate policies of these banks have kept the effective use of these institutions from spreading among the majority of farmers.

The second category of rice stockholder, the government, purchases rice from farmers, generally in the aman season. This rice and imported grains constitute the two sources of government stock. Storage cost plays a small role in the decisions of the government in fixing the harvest-season procurement price and the peak-season sale price. The government's share in the total marketable surplus varies tremendously across years. In several years of the period 1970-84 this share was as high as 30-40 percent, while in most years it ranged from 2-10 percent of marketable surplus.⁶

The third category, the full-time traders in rice, are the stockholders in the free market who share the remaining portion of marketable surplus. Their storage costs might be approximated by the interest rate in the organized financial markets, but most of the traders conduct trade based on their own capital, which may have a different opportunity cost than the market interest rate. The interest rate in commercial banks for short-term borrowing was about 4 percent during 1964/65 when the general rate of inflation was also about 4 percent. In 1983/84, similar borrowing from banks cost an interest rate of about 15-16 percent with an inflation rate of about 14 percent. The real rate of interest in commercial banks therefore does not appear to have changed much. On the face of it, one would expect that real storage costs and resulting seasonality in prices would also be stable during the early 1960s and the early 1980s. But the storage cost between the two periods could be different even if the real interest rate were the same because of the difference in the length of storage brought about by new technology.

New Technology, Rice Production, and Seasonal Prices

The new rice varieties (HYVs) have had a significant effect on growth in foodgrain production in Bangladesh. The trend growth rates were not significantly different between the periods 1960-70, 3.1 percent a year, and 1971-84, 2.9 percent a year. The growth rate was faster (about 3.6 percent) during 1975-84 than in any other period. However, the sources of growth between the 1960s and the post-1970 period were remarkably different.

The increase in acreage was the main source of growth during 1960-70, whereas improvement in productivity of land was the primary source during 1971-84. The share of acreage in the incremental production of rice during 1960-70 was 57.4 percent, and the share of yield was 31.6 percent. This pattern changed drastically so that the share of acreage was only 14.3 percent and that of yield was 69.2 percent during 1971-84 (Hossain 1984). That new technology in agriculture brought about this phenomenal change is supported by information in Table 12 and related to statistics on the use of modern inputs in agriculture (Table 13). The most striking feature of the changing pattern of rice production in Bangladesh is the increase in the average share of HYVs, which has risen from zero in 1960-62 to about 42 percent in 1982-84.

Three consequences of this technological progress in rice production are important for the seasonal pattern of rice prices. First, assuming that aus, aman, and boro rice come to the market within a certain time period after harvest, and this timing has not been changed by technology, one would expect the increased production and hence

⁶ These estimates are based on the quantities procured by the government in various years and on the estimates of gross marketable surplus determined by relating such surplus to gross production, as formulated in Ahmed (1981).

Table 12—Changes in the shares of different rice crops in total rice output, 1960-62, 1969-70, and 1982-84

Rice Crops	1960-62	1969-70	1982-84
		(percent)	
Aus local	25.42	24.63	15.13
Aus HYV	0.00	0.70	6.77
Aus total	25.42	25.33	21.90
Aman local	69.67	55.78	39.75
Aman HYV	0.00	1.08	14.37
Aman total	69.67	56.86	54.12
Boro local	4.91	8.91	3.60
Boro HYV	0.00	8.90	20.38
Boro total	4.91	17.81	23.98
All rice	100.00	100.00	100.00
All HYVs	0.00	10.68	41.52

Sources: Bangladesh, Bureau of Statistics, *Statistical Abstract of East Pakistan* (Dhaka: BBS, 1966); and Bangladesh, Bureau of Statistics, *Statistical Yearbook of Bangladesh, 1985* (Dhaka: BBS, 1986).

market supply to generate different degrees of downward pressure on market prices at different seasons, all else being the same. This is so because the effects of technology are quite different in different types (or seasons) of rice, as is clearly shown in Table 12. In comparing the shares of various types of rice in total rice output between 1960-62 and 1982-84, the table demonstrates that the share of boro rice has risen from about 5 percent to 24 percent, the share of aus rice has fallen moderately from 25 to 22 percent, but the share of aman rice has declined sharply from about 70 percent to 54 percent. Moreover, the production of early-harvested broadcast aman has dwindled, shortening the length of the aman harvest period. Of the 24 percent share of boro rice in 1982-84, a little more than 20 percent was HYV boro. HYV aus accounted for only 7 percent, and HYV aman accounted for 14 percent of total rice production in 1982-84.

Table 13—Trend in the use of modern agricultural inputs, 1960/61-1983/84

Years	Area Irrigated by Modern Methods	HYV Area	Use of Chemical Fertilizers
	(percent of net cultivated area)	(percent of cropped area)	(nutrient pounds/ cropped area) ^a
1960/61	0.3	...	2
1965/66	0.9	...	4
1969/70	2.6	2.1	9
1975/76	7.7	13.0	15
1977/78	9.4	13.4	24
1979/80	12.8	18.8	28
1980/81	13.6	21.0	28
1982/83	19.2	22.9	31
1983/84	20.3	23.6	36

Source: Mahabub Hossain, "Agricultural Development in Bangladesh: A Historical Perspective," *Bangladesh Development Studies* 12 (No. 4, 1984): p. 12.

Note: The ellipses indicate a nil or negligible amount.

^a The trend in the use of absolute quantities of fertilizers rises much faster than the use per cropped acre because of increased cropping intensity.

Second, the technological progress in rice cultivation has brought in its wake changes in the timing of planting, average growth period, and harvest of various rice crops. Therefore, the timing of market arrivals of harvested crops has also changed, with consequent effects on seasonality of prices. The time of harvest varies slightly among districts due to agroclimatic conditions; the average harvest time is that time when the major portion of the crop is harvested. The average harvest times of various rice types during 1960-62 and 1982-84 in the country as a whole are shown in Table 14.

Since market arrivals begin only two to four weeks after harvest, it is not difficult to unravel the source of shift in seasonal prices of rice, as shown in Figure 10. As a result of the new technology the second-lowest price level now occurs in September because the boro and aus harvests overlap somewhat during the month of August. This overlapping occurs because of the staggering of the boro harvests over two months. The delayed planting of the irrigation-based boro crop, which is sown on new land at higher elevations, is partly the cause. Moreover, the growth period of the new HYVs is about 30-40 days longer than that of the local varieties (Bangladesh Agricultural Research Council 1983, 1982). As the harvests of boro and aus have moved forward by about two months without any substantial change in the harvest period of aman, the peak price season has become the month of May in the posttechnology period compared with a peak price period around July during the pretechnology era. During the earlier period, boro was a much smaller crop than now, which is also reflected in the July peak.

Third, and closely related, is the question of storability of different types of rice, and the effect of storability on the seasonal pattern of prices. Aus rice is harvested in wet months, and its moisture content is generally high. Farmers find it difficult to dry aus rice sufficiently. The same can be said but to a lesser degree of HYV boro. The storability of local boro is moderately good to excellent. Because aman varieties are harvested in dry stalks, they have excellent storability. For this reason, as well as taste, farmers with a surplus tend to sell their HYV and aus rice and to keep the aman rice for home consumption and for sale in a later month when prices are higher. These factors also contribute to the peak price situation around the month of May and a second low price period just after harvest of aus and boro.

Relation Between Seasonality in Prices and Production

The discussion of seasonality of prices and its causal factors has been predominantly descriptive. To understand the process better and to appreciate the weights of various

Table 14—Harvest months for various types of rice, 1960-62 and 1982-84

Type of Rice	1960-62	1982-84
Local aus	July-August	July-August
HYV aus	...	August-September
Local transplanted aman	December-January	December-January
HYV aman	...	January-February
Broadcast aman	November-December	November-December
Local boro	April-May	April-May
HYV boro	...	June-July

Sources: The information for 1960-62 is based on Bangladesh, Bureau of Statistics, *Surplus Labour in Paddy Cultivation in East Pakistan, 1964/65* (Dhaka: BBS, 1965). The information for 1982-84 is based on various sample surveys for crop estimates of the Bureau of Statistics and on field surveys by the Bangladesh Rice Research Institute.

causal factors that may have potential as policy instruments, it would be desirable to translate the descriptive points to objective measures. Unfortunately, lack of appropriate, season-specific data frustrates attempts to make a comprehensive objective analysis of seasonality.

A theoretically consistent approach to conducting a causal analysis of seasonality would require data on both demand and supply determinants by seasons, including some variables or specifications that could account for traders' expectation of prices. However, season-specific information on income, procurement, public distribution, prices of substitutes, and market arrivals from domestic production is not available. The only available season-specific data expected to have an important influence on seasonality of prices are for production. Thus, aman, aus, and boro rice harvests may be treated as proxies of seasonal supply. A regression model relating the measure of fluctuation in seasonal prices with seasonal production is undoubtedly an underspecification of the causal relation. Nevertheless, an estimate of this relation is provided here in order to reinforce the common understanding that the pattern of seasonal production significantly influences seasonality in prices. The estimate of the equation is

$$\begin{aligned} \log S = 24.67 - 2.65 \log AMN + 0.73 \log BORAS; \\ (1.23)(-1.06) \quad (0.76) \\ \bar{R}^2 = 0.12, \end{aligned} \quad (13)$$

where S is the measure of seasonal fluctuations. S is measured by the difference of peak and trough seasonal prices after nominal prices are adjusted for the trend-cycle component. Therefore, it represents the band or amplitude of the pure seasonal and irregular factors of prices. AMN is the aman harvest and $BORAS$ is the sum of boro and aus harvests, which have overlapped for a short time in recent years. The t -values are in parentheses. The analysis covers 1976-84.

Although the explanatory power of the influence is weak ($\bar{R}^2 = 0.12$), and the level of significance of the coefficients is also poor, the direction of the relation may be of some value. On this basis, it can be concluded that an increase in aman production in any year reduces the band of seasonal prices, and the increase in the combined boro and aus production widens the band of seasonal prices. This result seems consistent with the earlier finding that the effects of seasonality were accentuated in 1976-84 compared with 1960-70. During 1976-84, the share of aman declined and the share of aus plus boro increased compared with their respective shares in 1960-70.

Quantitative analysis of factors causing seasonal variation in prices and measurement of the weights of each of these factors on seasonality remains an underexploited area of investigation. Systematic development of seasonal information will be a first requirement for conduct of such analyses in the future.

In summary, the relative independence of supply and demand factors, accompanied by inelastic supply and demand elasticities, has increased annual price variability during recent years. Supply factors and their interactions with imports have become more dominant in explaining fluctuation in annual prices. These developments imply that an accurate forecast of domestic production is a critical requirement for planning price stabilization measures, including the need for imports. New technology has not accentuated the underlying pure seasonality of prices, although random fluctuation in seasonal prices has increased in recent years. All these factors dictate that price stabilization should be organized on a more systematic basis than in the past.

INTERMARKET LINKS AND REGIONAL PRICES

As mentioned in the introduction, an examination of the strength of integration among the many spatially distributed markets that constitute the basis of aggregate price analysis may identify weaker links in the chain of markets, which then can be kept under special purview when price stabilization measures are implemented. Segmentation of markets, that is, a complete lack of integration, implies that a market with excess demand does not get feedback from another market with excess supply. Therefore, the transmission of prices between such markets is absent. Markets may not be segmented, however, but the degree of integration or the rapidity and extent of transmission of prices among markets may still be weak for technical and economic reasons (for example, monsoons, political strikes, or high transaction costs in trade). Market integration does not mean that prices across geographical regions should be the same. Intermarket price differences will exist because of differences in transportation costs. These differences should not impair the transmission of price signals and trade among markets. In this chapter most regional rice markets in Bangladesh are shown to be integrated. Therefore, the adoption of an aggregate approach in modeling the price stabilization program is appropriate. But, even though the overall integration of markets is evident, there are occasions and locations where market integration is weaker than normal.

Regional Price Differentials

The trade flow in rice generally follows the pattern of supply from the hinterlands to the main industrial and urban centers of Dhaka, Chittagong, and Khulna. In addition, deficit districts receive supplies from nearby surplus districts. On the basis of this pattern of trade flow, the price differentials between markets, reflecting the marketing margins in interregional trade, are estimated for aus and aman rice. The price differential is calculated as

$$(P_1 - P_2)/P_1, \quad (14)$$

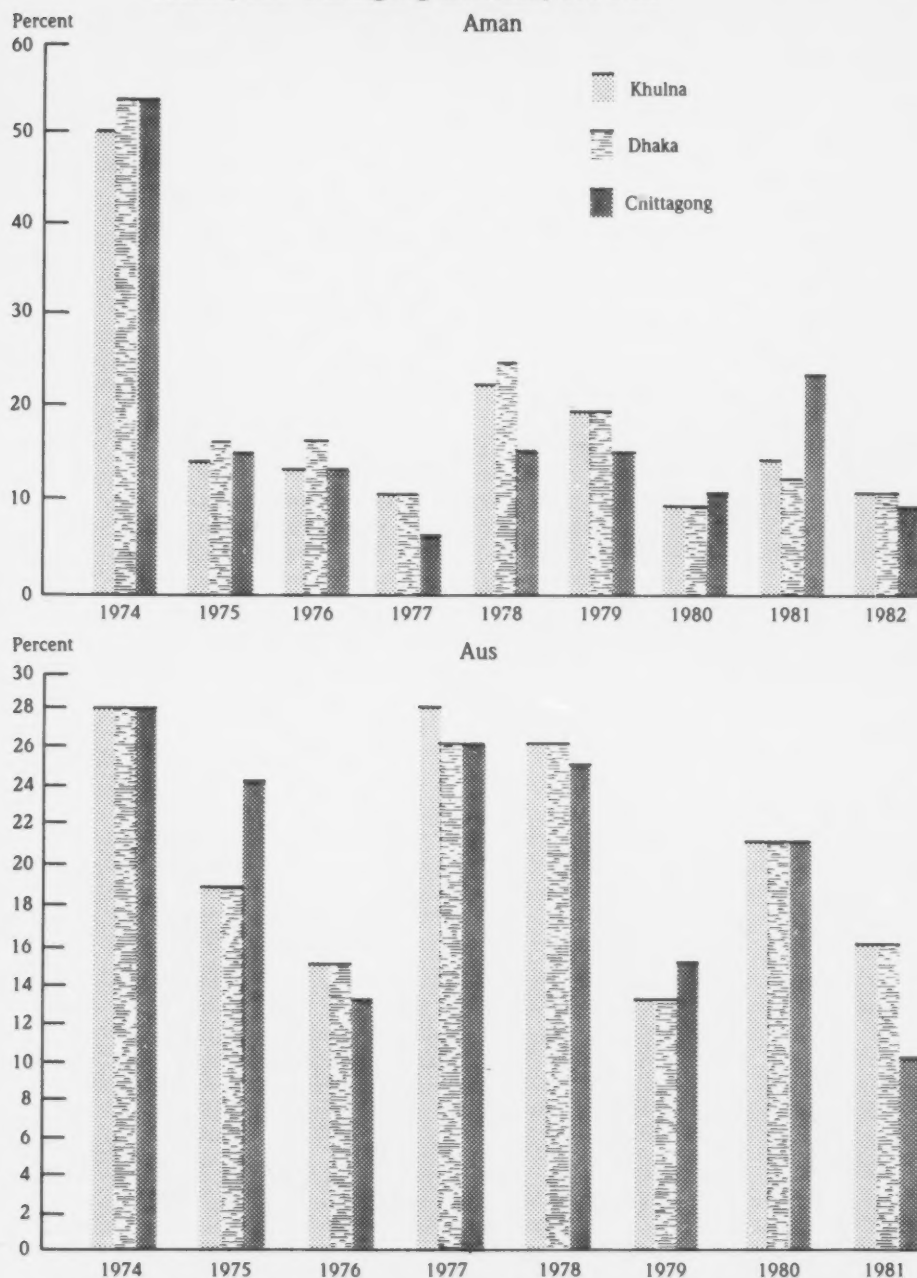
where P_1 is the price at the first market in a given year, and P_2 is the price at the second market in the same year.

The estimates of price spreads or spatial marketing margins vary considerably by region and by time. However, there is no guarantee that the pairs of markets with high marketing margins necessarily constitute trade channels with any substantial volume of trade. For example, the Dinajpur-Noakhali channel exhibits an average price differential of 22 percent with a standard deviation of 33 percent, but trade in this channel is infrequent and small.

This information is summarized graphically in Figure 12. The graph shows the difference between highest and lowest prices in the Dhaka, Khulna, and Chittagong divisions, expressed as a percentage of the highest price. A number of conclusions can be derived from this information.

Spatial price differences average about 15 percent in aman rice and 18 percent in aus rice, but this average proportion varies in different years. In 1974, the proportion

Figure 12—Intraregional price spreads for aman and aus rice in Khulna, Dhaka, and Chittagong divisions, 1974-82



Source: Computed from price data in Bangladesh Bureau of Statistics, *Statistical Yearbook, 1983/84* (Dhaka: BBS, 1985); and Bangladesh Bureau of Statistics, *Statistical Yearbook, 1985/86* (Dhaka: BBS, 1987).

rose to about 50 percent in aman and 28 percent in aus rice. Prices rose abnormally in 1974, particularly in the aman season. Recovery from disruptions in the market related to the civil war of 1972, particularly those involving movement of market functionaries, did not come about until that year. Even excluding 1974, spatial price margins appear to rise proportionately faster in years of rising prices.

This last point, that the proportion of the marketing margin rises with the rise in price levels, implies that either marketing costs increase with the rise in prices or traders reap an above-normal profit during such times. Perhaps the latter explanation is more realistic, and this may be the reason why policymakers distrust traders during periods of rising prices. However, such a phenomenon may not be irrational or an act of exploitation by traders if the relation between the marketing margin and level of prices is symmetrical. In that event, traders would make subnormal profits during a phase of falling prices, offset by above-normal profits during a phase of rising prices.

Methodological approaches to investigate the extent of market integration were initially limited to simple price correlations between markets. That such correlations are not always a proper indicator for market integration is evident from studies by Jones (1976), Harriss (1979), and Timmer (1974). Common factors like inflation, seasonality, and consistent price setting by public agencies may generate high correlation coefficients among market prices even though the underlying conditions are not congenial to an integrated market. Nevertheless, the correlation coefficients are not entirely meaningless. If the correlation coefficient between one pair of markets is higher than that for another pair, both operating under the same set of factors, obviously the former pair is more integrated than the latter. Therefore, the nature of integration in rice markets in Bangladesh is examined first through simple correlations and then through a somewhat more sophisticated approach suggested in recent literature (Ravallion 1986, Heytens 1986).

Interdistrict Correlations of Monthly Rice Prices

The paired correlation coefficients between district average prices of aman and aus rice are shown in Appendix 2, Tables 23 and 24. Price correlations during a period of rapidly changing prices could be different from those during a period of relatively stable prices. For this reason the correlation coefficients in stable and unstable years are worked out separately. In general, there is no difference in the number of significant coefficients between the stable and unstable years (years with less than or more than a 10 percent change in prices). However, the absolute magnitudes of correlation coefficients are slightly higher in unstable years. Only the coefficients for unstable years are presented in the tables. The locations of districts are shown in the map of Bangladesh (Figure 13).

The immediate observation that emerges from the correlation coefficients is that, measured by this indicator, aus rice markets are well integrated. Only 48 out of 190 pairs of correlations (about 25 percent) are statistically insignificant; all remaining coefficients are highly significant. Of the 48 insignificant coefficients, 18 relate Chittagong to other districts in the northern and southern parts of Bangladesh. Chittagong is one of the largest aus-growing districts. However, its transportation connections with districts in northern and southern Bangladesh are not well developed, inhibiting rice flows and perhaps causing insignificant correlations. Chittagong aus prices may need special monitoring during implementation of any stabilization scheme.

In the case of the aman price, there are 63 out of 190 pairs of correlations that are statistically insignificant. On this score, aman rice markets may appear to be less

Figure 13—Map of Bangladesh



integrated than aus. However, 51 out of the 63 insignificant correlations in aman prices pertain to Barisal, Patuakhali, Dinajpur, and Bogra. The first three are extremely backward in infrastructural development. Moreover, these districts again have larger shares of aman production than other districts. Therefore, concentration of production and backward infrastructure may be associated with disharmony in price movements between these three and the other rice markets of Bangladesh.

Application of an Advanced Test of Market Integration

Methodological developments for studying market integration are quite sparse. Ravallion (1986) developed a general approach to modeling market integration that can estimate the extent to which local prices are influenced by prices elsewhere. He employed this model with rice prices in Bangladesh just prior to and during the 1974 famine. His test of segmentation in rice markets rejected the hypothesis of segmented markets, but the test on short-run integration of markets was inconclusive. It must be noted that Ravallion's inquiry covered not only a period when a famine was raging in Bangladesh, but also a period just following a civil war when the country was still trying to recover from the infrastructural destruction wrought by that war. Ravallion's model has also been empirically applied by Heytens (1986) on Nigerian data. Timmer (1974) proposed a further use of the parameters from Ravallion's model to construct some indicators that will be explained later.

The Model

The estimating equation that was derived from Ravallion's general approach and used for the present study closely follows Heytens' discussion.

$$(P_{it} - P_{it-1}) = (\alpha_i - 1)(P_{it-1} - \bar{P}_{t-1}) + \beta_{i0}(\bar{P}_t - \bar{P}_{t-1}) + (\alpha_i + \beta_{i0} + \beta_{i1} - 1)\bar{P}_{t-1} + \gamma_i X + \mu_{it}, \quad (15)$$

where

- P_{it} = price in local market at time period t , i runs from 1 to n markets;
- $\bar{P}_t$ = price in the central or reference market (Dhaka in the present study);
- X = other factors used as dummies for dry or monsoon seasons;
- α_i, β_i , and γ = parameters of the model to be estimated; and
- μ_{it} = the error term.

The model specifies the change in local price as a function of the change in the Dhaka market price for the same period, last period's spatial price margin, last period's Dhaka market price, and local market characteristics. In equation (15) β_{i0} measures the extent to which the local price at a given time is influenced by the change in the central market price during the same time period. It therefore reflects the extent and the rapidity of movement of information from central market functionaries to wholesalers, retailers, or farmers in the local markets so that they can act to adjust prices.

The term $(\alpha_i - 1)$ measures the extent to which last period's spatial price differential is reflected in this period's local market price change. If the margin widened in the last time period (because of a price rise in the central market) and transaction costs remained the same, traders would have an incentive to move rice away from the local market to another part of the marketing chain, thus pushing up prices in the current time period. Other forces might also influence local price changes. Periodic shortages in supply or disruption of communications by local storms or cyclones could influence local price changes and sever the links with the central market. Finally, the general level of prices in the central market may provoke price changes in the local market,

as is generally considered usual in an inflationary environment. This is reflected by β_{11} .

From equation (15) the following hypotheses can be tested:

Market Segmentation. The hypothesis that the local market is segmented from the central market means that the changes in the central market price will have no effect, immediate or lagged, on prices in local markets. In equation (15) market i is segmented if

$$\beta_{10} = \beta_{11} = 0. \quad (16)$$

This can be determined by testing equation (15) against the following restricted model with an F-test:

$$(P_{it} - P_{it-1}) = (\alpha_i - 1)(P_{it-1} - \bar{P}_{t-1}) + \gamma_i X + \mu_{it}. \quad (17)$$

If equations (15) and (17) are equal according to the F-test, then $\beta_{10} = \beta_{11} = 0$ and markets are segmented.

Short-Run Integration. This hypothesis requires that changes in the central market price be immediately (within the same month in the case of monthly data) and fully reflected in the local price. In terms of equation (15) it means that

$$\beta_{10} = 1, (\beta_{11} = 0), \text{ and} \quad (18)$$

$$\alpha_i = 0. \quad (19)$$

If both equations (18) and (19) are satisfied, market i is integrated with the central market in the same time period. Acceptance of the hypothesis makes $\beta_{10} = 1$ and $(\alpha_i - 1) = -1$, indicating that this period's central market price change and last period's spatial differential are fully reflected in the current local price level.

Absence of Local Characteristics. This hypothesis implies that $\gamma_i = 0$, and therefore it reduces to

$$\begin{aligned} (P_{it} - P_{it-1}) = & Y_0 + (\alpha_i - 1)(P_{it-1} - \bar{P}_{t-1}) + \beta_{10}(\bar{P}_t - P_{t-1}) \\ & + (\alpha_i + \beta_{10} + \beta_{11} - 1)\bar{P}_{t-1} + \mu_{it}. \end{aligned} \quad (20)$$

More generally, specifications of the X variables are limited to dummy variables defined over the same time frame as each price observation (for example, monthly price data require monthly dummy variables). Such a general specification enables the use of dummies for monsoon and winter-season months. Seasonality factors, if each market has different seasonal prices, could also be used in the form.

Equation (15) can be tested against equation (20) with an F-test in order to determine the significance of local characteristics. Equation (15) can also be manipulated to result in an indirect but more subtle and general indicator of market integration. Assuming that the central market is stable,⁷ and there is no effect of local characteristics on local prices, then (α_i) and $(\beta_{10} + \beta_{11})$ indicate the relative contributions of past local and central market prices to the determination of the current local price.⁸ If past central

⁷ Stability means $(\bar{P}_t - \bar{P}_{t-1}) = 0$. It may appear unrealistic, but if one considers that the condition is devoid of seasonal and inflationary effects, it may not be so.

⁸ For consistency, Ravallion's notation is used throughout.

market prices are the primary influences on local prices, the local market is well connected in that central market supply and demand factors are being transmitted to local markets and influence prices there.

Timmer constructed an index of market connection (IMC) in order to measure the relative influences of these two sets of forces. IMC is defined as the ratio of the lagged local market coefficient to the lagged central market coefficient.

$$IMC = \alpha_1 / (\beta_{10} + \beta_{11}). \quad (21)$$

If Ravallion's short-run integration is accepted, then $\alpha_1 = 0$ and $IMC = 0$ when markets are segmented, $\beta_{10} = -\beta_{11}$ and $IMC = \infty$. Given the model's specification, $(\alpha_1 - 1)$ would be between 0 and -1 under normal conditions and the index would normally be positive. In general, the closer the index is to 0 the greater the degree of market integration. Timmer, allowing for the assumptions of stability in central market prices and the absence of local characteristics, considered that a value of IMC less than 1 reflected a high degree of short-run market integration.

Data for the Investigation

Data for such a sophisticated analysis have to be modestly disaggregated and accurate. For this reason, instead of using average prices at district levels, market prices at 67 Bangladesh markets were obtained from the Department of Agricultural Marketing. These were weekly prices for coarse and medium-quality rice, collected from periodic markets and aggregated to monthly averages. Preliminary examination of this data set revealed that information for certain months was missing for certain markets. The distribution of missing data, which reflects the extent of inactive markets (Figure 14), indicates that most of the missing data pertain to the months of July, August, September, and October. These are the months when rural transport and the communication system are handicapped by monsoon and postmonsoon rains and floods, and markets are occasionally disrupted by these natural hazards. Rice markets are also generally thin in September and October. This is a tentative indication that rice markets lack complete market integration, at least in the short run.

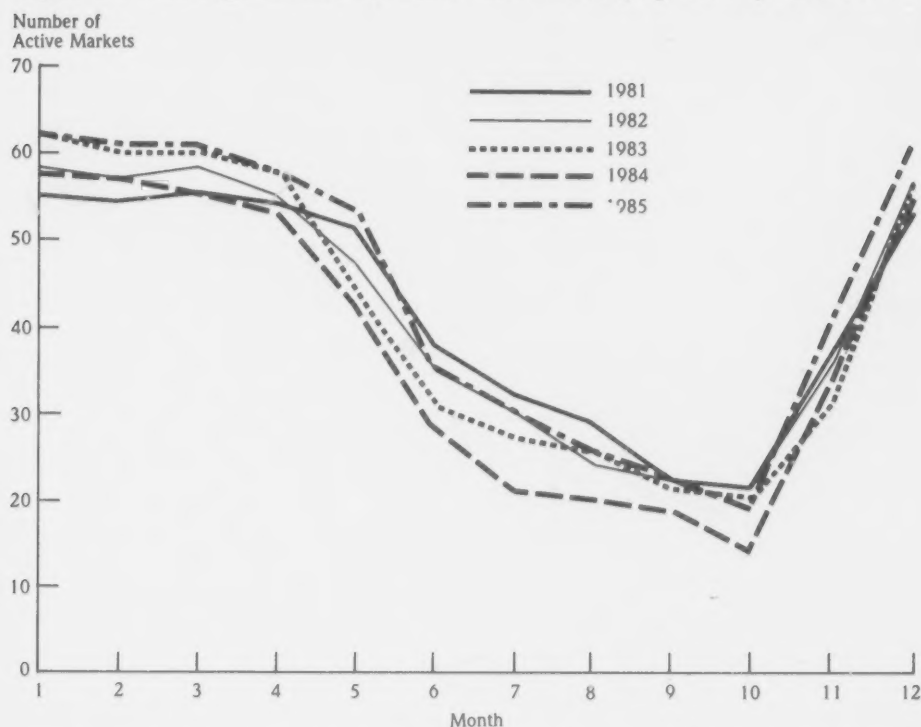
Because the analytical framework developed earlier requires that there be no missing data for any month for a market, only those markets that had price data for all months were selected. Only 19 out of 67 markets met this condition. This choice of markets may bias the results toward integration if only because the chosen markets were more active than those not selected.

Results

Segmentation of Markets. The error sum of squares (ESS) for restricted (equation 15) and unrestricted (equation 17) forms of the model and F-statistics for testing the hypothesis that markets are segmented are given in Table 15. The data cover the period 1981-85.

The hypothesis that a market is segmented—totally lacking in integration—where price changes in a local market depend only on past prices in that market is rejected at the 1 percent level of significance for every market. Most of the tested markets fall geographically within northern, western, and southern parts of Bangladesh; therefore, the conclusion is not valid for eastern and northeastern regions. Because eastern districts of Bangladesh are infrastructurally better connected with the central Dhaka market, market segmentation is less likely in these areas than in the areas covered by the tested markets (except in the Chittagong Hill Tract).

Figure 14—Average number of active rice markets, by month, 1981-85



Source: Weekly price data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

Short-Run Market Integration. A lack of total segmentation of markets does not imply that markets are well integrated or integrated at all times. The degree of integration may be weak, and this may be more so at certain times. The results for the hypothesis that the monthly prices on markets are integrated even in the short run are given in Table 16.

Timmer's IMC ratio for evaluating short-run integration was less than 1 in 3 cases out of 19, and the β_{10} coefficients were less than one standard error away from unity in 6 additional markets.⁹ Thus, at first glance, only three of the markets show any short-run integration or integration within the domain of monthly prices. Six others reflect Dhaka price changes without exhibiting signs of significant short-run integration. The rest are poorly integrated with the Dhaka market. However, as mentioned earlier, weekly data collected for 67 markets throughout Bangladesh showed a significant drop in the number of markets reporting prices during monsoon months. Thus, if a dummy for the rainy season is added to acknowledge that markets may be well connected

⁹ If β_{10} is close to one but the IMC is high, short-run integration is not likely; yet reference market price changes are being passed along. In this study, that result is viewed as a sign of some integration.

Table 15—Results of a test for segmentation of markets, using the error sum of squares, 1981-85

Market	District	Error Sum of Squares		F-Statistics
		Unrestricted	Restricted	
Joypurhat	Bogra	0.1562	0.3174	28.893
Gaibandha	Rangpur	0.1559	0.3791	40.082
Rangpur	Rangpur	0.0801	0.1748	33.081
Kurigram	Rangpur	0.1359	0.2909	31.923
Rajshahi	Rajshahi	0.1016	0.2201	32.664
Nowabganj	Rajshahi	0.1141	0.2526	34.022
Natore	Rajshahi	0.0680	0.1841	47.859
Naogaon	Rajshahi	0.1010	0.2195	38.142
Dinajpur	Dinajpur	0.1483	0.2957	27.847
Thakurgaon	Dinajpur	0.0909	0.2147	38.171
Sherajganj	Pabna	0.1124	0.2759	40.716
Kushtia	Kushtia	0.0568	0.1475	44.785
Chuadanga	Kushtia	0.0509	0.1358	46.736
Jessore	Jessore	0.0919	0.2476	47.438
Khulna	Khulna	0.1003	0.2258	35.049
Barisal	Barisal	0.1276	0.3081	39.187
Jhalkati	Barisal	0.1514	0.3612	38.815
Patuakhali	Patuakhali	0.2593	0.5255	28.757
Faridpur	Faridpur	0.0507	0.1540	57.076

Table 16—Results of a test for short-run integration of markets, using the index of market connection, 1981-85

Market	Index of Market Connection			β_{10} Coefficient
	Dry Season	Monsoon Season	Whole Year	
Joypurhat	1.52	2.71	2.72	0.98
Gaibandha	0.60	1.88	1.55	1.05
Rangpur	NS	1.83	2.84	0.82
Kurigram	2.01	NS	0.87	0.79
Rajshahi	1.06	1.28	1.36	0.81
Nowabganj	0.94	1.74	1.46	0.85
Natore	0.78	NS	1.79	0.83
Naogaon	NS	2.24	1.09	0.78
Dinajpur	0.48	0.76	1.03	0.81
Thakurgaon	NS	1.24	1.31	0.79
Sherajganj	1.11	2.30	2.42	0.97
Kushtia	1.75	NS	1.44	0.77
Chuadanga	0.50	1.50	0.87	0.73
Jessore	0.70	NS	0.50	0.84
Khulna	1.35	1.71	1.78	0.85
Barisal	1.40	1.35	2.10	0.98
Jhalkati	1.46	1.40	2.54	1.09
Patuakhali	1.08	2.27	1.89	1.11
Faridpur	0.80	NS	1.54	0.81

Notes: NS means the number is nonsignificant. β_{10} measures the extent to which the local price is influenced by a change in the central market price.

during part of the year but poorly linked in other months due to adverse weather, just under half of the markets (9 out of 19) are highly integrated with the central market during the dry season (three others have β_{10} near one). Even in the dry season about 36 percent of the markets are relatively weak in intermarket linkages. During the monsoon season (July-October) about 74 percent (14 out of 19) of the markets are poorly integrated (their IMC is greater than one), and 26 percent remain highly integrated with the central market even in the monsoon months.

Policy Implications

In the context of the present study, the analysis of market integration has the following implications:

First, the absence of segmentation of markets, as evidenced by the various tests, implies that price analysis at the aggregate level is valid. If it were not, the stabilization program and its associated model would have required as many versions as there were independent segments in the market.

Second, even though the markets are not segmented, the degree of integration (the extent and rapidity of transmittal in price signals from one market to another) is weak at some market locations and at some times of the year. This implies that the government cannot be sure that, by undertaking procurement or open market sales in only a few centers, it will automatically influence prices in all markets. In the aman season, particularly for procurement, a greater than normal effort may be required for successful procurement drives in Dinajpur, Patuakhali, Barisal, Bogra, and Rajshahi. In aus season, procurement efforts should focus on Chittagong division in particular and on the Jessore-Kushtia belt in general.

Third, although the present study is geared to short-run price stabilization issues, a long-run solution also lies in development of infrastructure in the northern and southern parts of Bangladesh, which would strengthen integration of markets and facilitate the efforts of the price stabilization scheme.

AN APPROACH TO PRICE STABILIZATION

The extent of the price fluctuation shown in Chapter 4 raises an important question. Why has Bangladesh not been as successful as Indonesia in reducing price fluctuation, despite roughly the same amount of public expenditure on intervention in the foodgrain market? After all, the two economies do not differ greatly in population, consumption patterns, and cropping patterns. Indonesia has been able to reduce both inter- and intrayear fluctuations in rice prices from 50-60 percent in the 1960s to 10-15 percent in the second half of the 1970s (Mears 1981). The difference can be traced to the orientation of the two programs. In Indonesia, stabilization of prices through targeting of ceiling and support prices within a price band is the principal policy objective. In Bangladesh, meeting quantity targets for various public distribution conduits is the principal explicit objective, while price stabilization is a secondary and implicit objective. In this chapter a framework for price stabilization, where policy objectives are enunciated as prices rather than quantities, is outlined. Quantities, however, are derived from prices in a consistent manner. After all, quantities are unavoidable for budgetary purposes. The framework is designed to be used by the government for planning the public-sector foodgrain program before the preparation of the annual budget. The Planning, Finance, and Food ministries should all find it helpful.

The framework consists of an analysis of the costs associated with a target price-band policy. The task requires the following steps:

1. Develop a short-term model for prediction in April-May of the annual average price most likely to prevail during the following July-June financial year;
2. Link the seasonal variations in prices, as analyzed in Chapter 4, to the predicted annual prices in order to arrive at predicted seasonal prices;
3. Estimate costs associated with various price bands in order to indicate the trade-off between the degree of price stability and the cost; and
4. Establish operating rules for managing annual and seasonal prices that should be consistent with the framework.

The details of these steps will be discussed further after a brief account of the current practices in management of the foodgrain system, which is necessary to clarify the differences between these practices and the proposed changes

Current Practices in Public Foodgrain Management

The public foodgrain system is based on a set of policies and an organizational structure designed to implement these policies. The Food Department, the primary organization, consists of a number of branches entrusted with the tasks of distribution, procurement, storage, transportation, inspection, and control. Publicly owned storage facilities have been developed to a capacity of 1.85 million tons in 1984, and these capacities are spread throughout the country. Major policy decisions are made at the highest level by the Ministers of Planning, Finance, Food, and Agriculture and the President. Initiative for changes in policies may come from any of these ministries, even though the formal processing of documents is conducted by the Food Ministry. A food policy monitoring cell assists the Secretary of Food in this process of policy formulation.

The normal exercise in short-run policy formulation begins in January or February and culminates before the preparation and finalization of the annual public budget on June 30. This budget pertains to the following financial year (for example, the budget presented on June 30, 1984, relates to July-June 1984/85). Extraordinary changes in policies may be made at any time. The budget exercise is comprehensive. It includes targets on revenue collection, foreign aid, current and capital expenditures, money supply and credit, the general inflation rate, exports, imports, production of trade-related goods, administered prices, and subsidies, and many others (see Bangladesh, Ministry of Finance 1985a and 1985b, and Bangladesh, Ministry of Planning 1985 for a sample of references).

In the context of the foodgrain system the budget exercise includes targets on how much grain is to be imported, how much is to be procured from domestic production, and how much is to be distributed through various public conduits. These targets are arrived at following procedures that do not explicitly incorporate a simultaneous and consistent price target for the market. This is what is meant by the characterization of the current policy as oriented to "quantity target rather than price target." The basis of arriving at these targets will be discussed further when quantitative relations concerning imports, procurement, and distribution are estimated. The formulation of these targets is influenced considerably by recent experience, political consideration, and most importantly, the prospect of domestic production. For example, how much foodgrain would be imported is normally estimated on the basis of a forecast of domestic production, the normal consumption requirement (generally 16 ounces per capita per day), and availability of food aid. In years not considered to be normal (politically unsettling years, election years) this rule may be violated to increase the import target. At the time of budget preparation, aus rice production is approximately known, but aman and boro rice and wheat production are only forecasts. Thus, considerable uncertainty surrounds the initial targets, but it may be possible to make corrections as information becomes more certain with the passage of time.

Government procurement from domestic production is voluntary on the part of sellers. Through its network of storage and purchasing centers, the government makes purchases at harvest time from farmers and small traders. Procurement target and procurement price are determined at the time of budget preparation. Past experience, production prospects, price trends, and stock in public godowns are some of the considerations that enter into the target determination. No formal procedure exists to check whether these targets are consistent with prospective prices.

Public distribution consists of rationing channels, open-market sales, relief grants, and food-for-work allocations. The rationing channel is divided into a number of outlets. Broadly speaking, urban consumers are subsidized through statutory rationing and rural consumers through modified rationing, though the latter channel is relatively small and irregular. Private, licensed dealers do the actual job of selling to ration card holders at regulated prices and predetermined quotas (see BECON 1986 for details). Open-market sales of foodgrains are still quite thin. These sales are the only component of the system that allows for direct action to bring down prices when the price level becomes too high. After this brief account of the current system, the main objective of developing a framework for price stabilization can be addressed.

A Model for Short-Term Price Determination

If planning for stabilization has to precede actions, it is vital that the government be able to predict price levels in the upcoming year, at least with a moderate degree

of reliability. The purpose of the model is, therefore, to predict an average annual price of rice that is valid for the upcoming budget year. Two considerations bear the utmost importance in developing this model. First, the model should be simple enough for staff economists and other professionals working at the country level to be able to work with it. In particular these professionals must be able to insert new values for variables as they become more certain and then reevaluate the price. Second, though simple in structure, the model should have reasonably strong predictive power. Prediction of prices is generally a frustrating task. The experiences of international organizations in predicting prices of commodities in international markets bear testimony to this frustration (Mellor and Ahmed 1987).

A Fully Specified Model

If determination of prices is to be based on underlying supply and demand parameters, then the framework should be a fully specified structural model that will provide predicted price along with consistent estimates of supply and demand parameters. Such a structural model for rice in Bangladesh is formulated as follows:

$$\text{Demand for rice: } MDR_t = f(Y_t, PR_t, SW_t), \quad (22)$$

$$\text{Supply of rice: } MSR_t = QR_t - QRP_t + RDP_t, \quad (23)$$

$$\text{Public procurement: } QRP_t = f(QR_t, PR_t, ADP_t, OS_t), \quad (24)$$

$$\text{Public distribution of foodgrains: } RDP_t = f(PR_t, ADPR_t, Z_t), \quad (25)$$

$$\text{Stock available to government: } Z_t = OS_t + MP_t, \quad (26)$$

$$\text{Opening stock: } OS_t = OS_{t-1} + QRP_{t-1} + MP_{t-1} - RDP_{t-1}, \quad (27)$$

$$\text{Import of grains: } MP_t = f(GAP_t, FA_t, WP_t), \text{ and } \quad (28)$$

$$\text{Demand-supply balance: } MDR_t = MSR_t, \quad (29)$$

where the expected signs of the partial derivatives are as follows:

$$\begin{array}{lll} \partial MDR_t / \partial Y_t > 0 & \partial MDR_t / \partial PR_t < 0 & \partial MDR_t / \partial RDP_t < 0 \\ \partial MDR_t / \partial SW_t < 0 & \partial QRP_t / \partial QR_t > 0 & \partial QRP_t / \partial PR_t < 0 \\ \partial QRP_t / \partial ADP_t > 0 & \partial RDP_t / \partial PR_t > 0 & \partial RDP_t / \partial ADPR_t < 0 \\ \partial RDP_t / \partial Z_t \geq 0 & \partial MP_t / \partial GAP_t > 0 & \partial MP_t / \partial FA > 0 \\ \partial MP_t / \partial WP_t < 0, & \partial QRP_t / \partial OS_t < 0 & \end{array}$$

where

MDR_t = market demand for rice in tons per capita,

Y_t = per capita real income in taka,

PR_t = price of rice in real terms (nominal price deflated by the index of manufactured goods' prices),

- SW_t = per capita production of wheat,
 MSR_t = market supply of rice in tons per capita,
 QR_t = per capita production of rice,
 QRP_t = public procurement from domestic production per capita,
 RDP_t = distribution of foodgrains per capita from the public rationing system,
 ADP_t = administrative procurement price in real terms,
 OS_t = opening stock of foodgrains per capita in government godowns,
 $ADPR_t$ = administrative ration price in real terms,
 Z_t = availability in government stocks,
 MP_t = import of foodgrains per capita,
 GAP_t = per capita gap between domestic availability of foodgrains and estimated requirements based on 16 ounces per capita per day,
 FA_t = food aid per capita,
 WP_t = world price of foodgrains (weighted average price), and
 t = year ($t = 0, 1, 2, \dots, n$).

The supply equation (23) has been formulated without a price variable in the argument because, at the time of the prediction exercise, production estimates of two out of three rice crops—aus and boro—are already known and the first forecast of the third (aman) is available but speculative.¹⁰

The eight equations above can be reduced to six by substitution of equations (22) and (23) in equation (29). These six equations can provide solutions for six of the endogenous variables: PR_t , RDP_t , QRP_t , Z_t , MP_t , and OS_t .

The equations are estimated by the three-stage least square method for estimation of a simultaneous system using the analysis with the limited dependent variables (LIMDEP) computer software program. The estimated equations are presented in Appendix 2, Table 25. The difference between the predicted and actual prices from this model is quite large in most years. The direction of relationship as indicated in the estimated equation is correct in almost all cases but the reliability of the coefficients is often quite low. For example, the estimated coefficient of the income variable (equation 22) shows the expected sign, but the t-statistic of the estimate is beyond the acceptable level of significance. The coefficient of wheat output (SW) can be interpreted as the additional units of rice demanded in substitution for a unit change in wheat

¹⁰ For the purpose of estimation of this and the other model in this study, boro rice in 1983/84 is found to be relevant for the 1984/85 market supply.

supply. This coefficient is expected to be negative but less than one in the context of the taste pattern in Bangladesh. The sign of the coefficient is correct but its absolute value is 4.2, substantially greater than one. Because the wheat price series was incomplete for the entire period, price could not be used for the supply of wheat in equation (22). Wheat is a relatively new product, which has gained substantial importance in the domestic production of grains only in recent years. Among the various equations in the system, the estimates of import equation (28) were found to be quite reliable, except for the coefficient of world price (WP).

Why this poor result with such a complete system? The following reasons may underlie the frustrating results. First, the 1960-84 (excluding 1972-75) data series had to be used to give enough degrees of freedom for reliable estimates. But the data pertaining to the 1960s are not reliable, particularly for certain variables. During this period Bangladesh (formerly East Pakistan) was a part of Pakistan and some statistics, such as per capita income and imports in certain years, were not originally available as direct measures. They were derived by various researchers for various purposes and therefore estimates vary considerably. Second, the economy of Bangladesh underwent significant structural changes after 1971, particularly for factors that affect prices. Thus, procurement from domestic production was mostly compulsory in the 1960s, while it was voluntary after 1970. The public distribution system has changed, with more administrative prices used to control offtake now than in the past. The political power structure accords higher priority to special groups and food-for-work outlets than was the case in the 1960s. Moreover, farmers now market about 30-35 percent of rice production compared with only about 10 percent in the early 1960s.

An Alternative Model

The foregoing discussions indicate that the prediction of price has to be based on a shorter data series, 1976-84, for example. Moreover, the emphasis is on prediction rather than estimation of parameters of supply and demand, even though these parameters are implicit in the price prediction model. The following price equation was the central basis for the prediction of price:

$$PR_t = f(Y_t, MSR_t, SW_t). \quad (30)$$

Price is shown in equation (30) as dependent on income, market supply of rice, and wheat production. Market supply consists of domestic production minus public procurement plus distribution from public stock. As explained earlier, domestic production, during the short period in question, is not a function of price. But public procurement and distribution are influenced by price as shown in equations (24) and (25) of the fully specified model.

Therefore, the system of equations adopted in this model consists of equations (30), (24), (25), and (23), where the expected signs of partial derivatives are $\partial PR_t / \partial Y_t > 0$, $\partial PR_t / \partial MSR_t < 0$, and $\partial PR_t / \partial SW_t < 0$. Other partial derivatives are expected to behave as indicated before.

In this system there are four endogenous variables and four equations; therefore, it is possible to find solutions for the four unknowns (PR_t , QRP_t , RDP_t , and MSR_t). Inspection of each equation further shows that the number of endogenous variables appearing on the right-hand side is less than the number of exogenous variables excluded from the relation; therefore, the parameters can be identified. The econometric estimation of the system was made by using the three-stage least square method and the LIMDEP computer software with the 1976-84 data set.

This abridged model differs from the complete one in the price equation used in place of independent supply and demand equations, the treatment of Z_t and OS_t as exogenous rather than endogenous, and the omission of the import (MPt) equation. Z , OS , and MP are interrelated. The equations for both Z and OS are identities. Therefore, treatment of MP as exogenous is implicit. Is it reasonable to assume MP as exogenous? In the very context of forecasting short-run prices when domestic production shortfalls are largely known, the treatment of MP as exogenous is not unrealistic. It is shown in Appendix 2, Table 25 that import decisions are mostly explained by the size of the gap in domestic production and the availability of foreign aid. These two variables are exogenous. Therefore, the implicit treatment of MP and the explicit use of Z and OS as exogenous are not as objectionable as it may appear. Moreover, single-equation ordinary least squares as well as simultaneous equation estimates show that OS has no influence on procurement and Z has only modest influence on public distribution. These variables are not significant.

The estimated equations of this system [equations (30), (24), and (25)] are presented in Table 17. Equation (23) is an identity. Data for the analysis are shown in Appendix 2, Table 26.

The Price Equation

The estimate of the price equation (30) is reasonable. The derived price and income elasticities of demand are -0.52 and 0.46 . These are consistent with estimates made earlier by other researchers (Mahmud 1981, Ahmed 1979). The income variable is lagged by one year to accommodate the flow of the income measured from the production account of national product to expenditure streams with a time lag. The variables MSR and SW are measured in tons per 1,000 persons, Y in taka per person, and PR in taka per maund. The nominal rice price is deflated by the manufactured consumer goods prices, and GNP is deflated by the general price index. The effect of wheat supply (domestic wheat production) on rice price is statistically not significant even though the direction of effect and the size of the coefficient are consistent with intuitive judgments. An increase in production of wheat is expected to depress the rice price

Table 17—Estimated equations of the rice price system

Equations and Variables	Coefficient Estimate	t-Value	Elasticity at Mean Values
Equation (30): price			
Constant	412.95	2.04	...
Y_{t-1}	0.08	4.80	0.88
MSR_t	-2.28	-1.97	-1.94
SW_t	-1.13	-0.36	-0.05
Equation (24): procurement			
Constant	39.92	1.49	...
QR_t	-0.25	-0.32	...
PR_t	-0.28	-2.61	-14.65
ADP_t	0.33	2.37	10.55
OS_t	-0.04	-0.17	...
Equation (25): ration distribution			
Constant	18.98	12.05	...
PR_t	0.06	1.90	0.76
$ADPR_t$	-0.15	-3.94	-1.21
Z_t	0.12	1.13	0.21

due to the substitution effect. Wheat production is only about 8 percent of rice production in recent years. Therefore, its effect on rice price through substitution in consumption is bound to be weak.

The Procurement Equation

Earlier efforts to estimate the procurement equation (24) in a single equation model were not satisfactory, but the estimated equation in a simultaneous system proves to be quite rewarding. The effect of rice production, QR , on procurement is not significant. The market price of rice and the administered procurement price exert significant influence on procurement of rice. The direction of the relation is correct, and the elasticities of procurement for these two prices are quite high but not equal, which indicates that the effects on procurement of market price and administered price are not symmetrical. It must be remembered, however, that procurement is a seasonal activity and estimation of the equation within a framework of annual statistics may not provide a complete picture, even though the effect of prices on procurement is clearly established. Various nonprice factors (the extent of purchasing centers, financial resources at the disposal of the procurement agency, and so forth) could play important roles. These factors should not be ignored when procurement decisions are formulated in the context of the price stabilization program enunciated here.

The Ration Equation

The estimated equation for per capita ration offtake (equation 25) also gives good results. It is apparent that both the market and administered ration prices in real terms have correct signs; however, administered price has a much stronger effect on the level of offtake. These results confirm recent findings that relative prices have become more influential in determining foodgrain offtake from the public system in recent years (Montgomery 1985). Availability of government stock (Z) is only a weakly significant factor in determining the level of public distribution.

Predictive Power of the Model

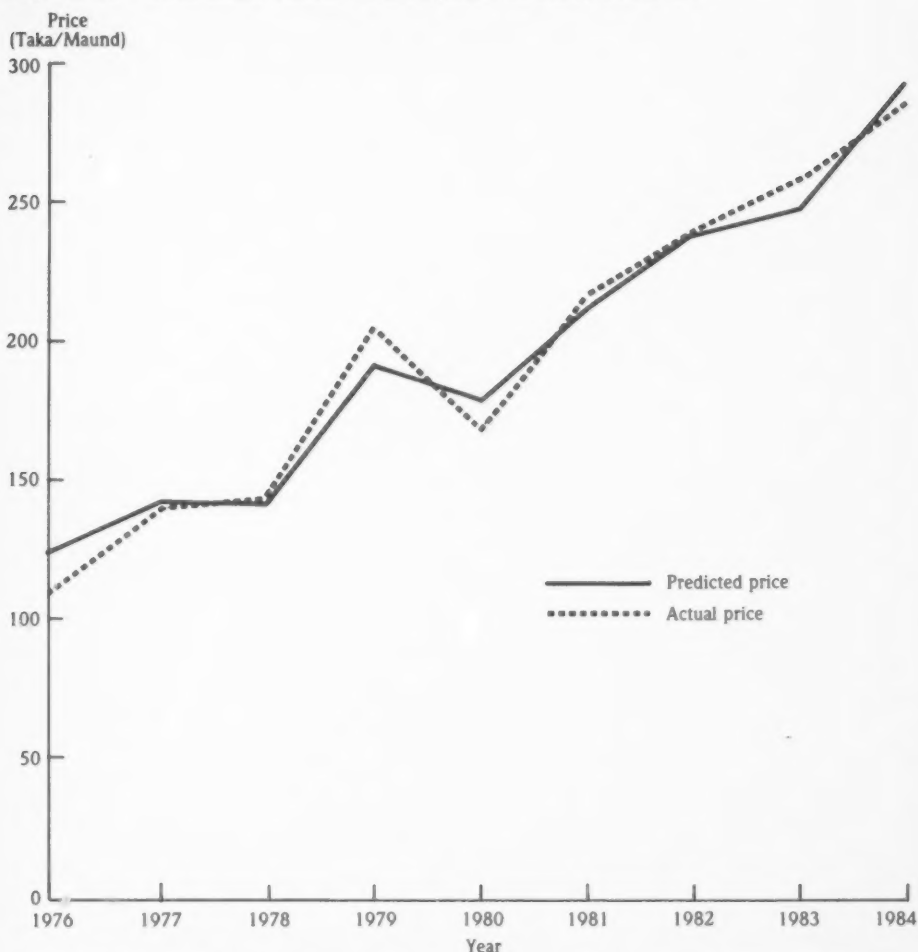
How reliable is the model in predicting rice prices in Bangladesh? One way to determine this is to see how well the predicted values fit actual past prices (see Figure 15). The predicted prices for various years are obtained by inserting the values of exogenous variables in each year in the estimated equations of the alternate model (equations 30, 23, 24, and 25) and then solving for the endogenous variables in a simultaneous manner, using a computer program. The predicted prices thus obtained are converted to nominal terms by multiplying the real prices with the deflators.

It is reassuring that the model is remarkably consistent with historical experience. However, whether it will continue to be so in the future depends partly on the capacity of users to update the model as time passes by. Moreover, users will have to keep this monitoring mechanism up-to-date to take into consideration effects of nonprice factors (such as election-year actions, booms in construction activity, and floods). Only local analysts can assess these factors and modify predictions accordingly.

Application of the Model to Price Stabilization

Using the framework developed above to stabilize prices involves several steps. In the first step, prices are predicted from the production forecast in order to select a target annual average price. According to the concept, a price band that reflects norma-

Figure 15—Predicted versus actual price of rice, 1976-84



Source: Actual prices are from data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

tive as well as efficiency considerations provides the domain from which a particular price target is selected. In the second step the annual average price is linked with the seasonal pattern of prices, which provides a guideline for the seasonal activities of procurement and distribution of foodgrains that should be consistent with the average price target. The third step stipulates the operational rules for organizing domestic procurement and distribution as basic instruments for stabilization.

Price Band

Within what band of prices should a country stabilize its annual real prices of foodgrains? A narrower band costs more, whereas a wider band provides a smaller degree of stabilization but costs less. One reason costs rise as prices become more

stable is because private traders react to price stabilization policies of governments. When the band is so narrow that it does not allow private traders to make a normal profit from stocking foodgrains, the government has to undertake an increasing amount of stocking and market operation to bring about the desired degree of price stability, and this implies an increasing rate of cost. On the benefit side, a higher degree of price instability not only affects producers and consumers in the ways described in Chapter 3, but it strains the limits of political tolerance to instability in foodgrain prices. It is assumed, in the context of Bangladesh, that political tolerance is the deciding criterion for selecting the degree of price stability and the price band. This assumption derives its validity from the behavior of the government in management of food policies during the past decade.

Even though political considerations play a dominant role, cost considerations are also important. The incremental quantity of foodgrains that the public system should be prepared to sell on the open market and the costs of price stabilization are shown later. Here the procedure for arriving at a price band is specified.

For operational purposes, nominal prices are relevant. The conversion of real to nominal prices and the derivation of a price band in nominal annual prices is accomplished through the following formulation. Suppose that NP_0 is the nominal normal price in the base year, NP is the nominal price in the price band in the following year, v is the annual price band in real terms (a 4 percent band, for example, implies 4 percent up and 4 percent down), and i is the rate of inflation. Then the upper bound is $NP_U = NP_0[1 + (i + v)]$ and the lower bound is $NP_L = NP_0[1 + (i - v)]$. For example, when the base-year nominal price is Tk 300 per maund, the expected inflation rate is 10 percent, and an annual price band of 4 percent is chosen, then the upper-bound nominal price is Tk 342 and the lower-bound nominal price is Tk 318. It is clear that the lower-bound nominal price can be below the price in the base year when the inflation rate is smaller than the price band as defined here. Historical price data in Bangladesh show that nominal prices in some years have fallen below the prices of previous years even when inflation rates were positive.

Linking Annual and Seasonal Prices

The crop harvest seasons and seasonality of prices that have prevailed in recent years were explained in Chapters 2 and 4. For the purpose of price stabilization three trough and peak price seasons are relevant. These are the second-lowest price season (S_1), generally prevailing in the months of July-August-September; the lowest price season (S_2), prevailing in December-January; and the peak price season (S_3), prevailing during April-May-June. Prices in other months fall in intermediate zones having little relevance for price stabilization. The relationships between these seasonal prices and the annual price can be written as follows:

$$PS_1 = PA(SF_1), \quad (31)$$

$$PS_2 = PA(SF_2), \text{ and} \quad (32)$$

$$PS_3 = PA(SF_3), \quad (33)$$

where PS is the seasonal average price of rice in a particular season, PA is the annual average price of rice in a particular year, and SF is the seasonal factor (see Chapter 4). The actual price in any season of a year would be different from the estimated price on the basis of this formulation, because of these irregular factors unrelated to domestic

production. Prices in the same season of different years are explained by the difference in annual prices as well as these irregular factors. Thus, annual prices capture trend or inflationary effects when year-to-year comparisons in nominal seasonal prices are attempted.

It is obvious that the average annual price picks up the inflationary factor all at once, even though a certain rate of inflation in a given year may be distributed over the seasons or months within that year in an increasing or a decreasing order. This fine-tuning of the link between annual and seasonal prices can be undertaken if distribution of inflationary forces within a year can be obtained. The analysis of the trend-cycle factor, presented earlier, indicates that in different years there are different patterns of distribution of the monthly trend-cycle factors. In years of normal inflationary force this fine-tuning may not be necessary, but in abnormal years such sequencing of inflationary factors is unavoidable.

Using the example in the previous section where the upper-bound annual average price was estimated at Tk 342 and the lower-bound price at Tk 318, the seasonal prices related to that price band can be determined. Suppose the annual target price within the Tk 342-318 range in a particularly bad crop year is Tk 342. Then the peak season or ceiling price with a seasonal factor of 8 percent (typical of Bangladesh) is Tk 369 and the S_2 , the slack or harvest season price (or support level for price), is Tk 315. In a good crop year when the target price is the lower-bound annual average price of Tk 318 per maund, the relevant ceiling or peak season price for this year would be Tk 343 and the support or harvest season price would be Tk 293 per maund.

Simulation of the Stabilization Model

The simulation exercise reflects the price stability and application of policy instruments that would have prevailed during 1976-84 had the stabilization model formulated here been in operation then. This exercise is based on the assumption that a 4 percent price band in annual prices and an 8 percent price band in seasonal prices are the ranges within which the government allows prices to vary with changes in domestic production. In light of the earlier discussion, these price ranges are consistent with private trade making a normal profit.

The simulated and actual price regimes for rice shown in Table 18 are developed according to the following procedures.

1. The predicted prices (column 1, Table 18) are derived from the solution of the alternate model described earlier. The real prices are converted into nominal terms using the price deflator.

2. Then the normal prices—the trend prices for each year—are estimated from the trend equation based on 1968-84 time series (excluding 1973/74 and 1974/75). If for any year the predicted price is higher or lower than the normal price, then the upper- or lower-bound price is selected as the target annual price (column 2). For example, in 1976/77 the normal price, Tk 112.3, is lower than the predicted price, Tk 124.3. Therefore, the target price is derived by multiplying the normal price by the factor 1.04. The year 1978/79 demonstrates the case when the lower-bound price becomes effective. In this year, the trend or normal price was Tk 154.3, which was higher than the predicted price of Tk 142.6. Therefore, the target annual price for 1978/79 is Tk 148.1 ($154.3 \times 0.96 = 148.1$). See Appendix 3 for notes on modifying the procedure in future years and for adjusting the long-run price alignment.

3. The target floor price is obtained by multiplying the target annual price by the seasonal factor of 0.92 (1.00-0.08). Similarly, the target ceiling price is derived by multiplying the target annual price by the seasonal factor of 1.08.

Table 18—Actual prices of rice, 1976/77-1984/85, compared with prices simulated by the model

Year	Predicted Annual Price	Target Annual Price ^a	Target Ceiling Price	Target Floor Price	Actual Annual Price	Actual Ceiling Price	Actual Floor Price	Difference Between Actual and Target Prices		
								Ceiling ^b	Floor ^c	Annual ^d
				(taka/maund) [*]					(percent)	
1976/77	124.3	116.8	126.1	107.5	110.0	129.9	98.1	3.0	8.7	6.2
1977/78	142.2	138.6	149.7	127.5	139.0	150.0	125.0	0.2	1.9	-0.3
1978/79	142.6	148.1	159.9	136.3	144.9	183.0	129.0	14.4	5.3	2.2
1979/80	191.5	182.3	196.9	167.7	204.7	233.0	182.0	18.3	-8.5	-10.9
1980/81	178.1	188.5	203.6	173.4	168.9	180.8	155.9	-11.2	10.1	11.6
1981/82	211.6	208.6	225.3	191.9	216.3	291.0	181.0	29.1	5.6	-3.7
1982/83	237.2	228.8	247.1	210.5	239.6	265.0	218.0	7.2	-3.6	-4.5
1983/84	247.7	248.9	268.8	229.0	257.2	282.0	233.0	4.9	-1.7	-3.2
1984/85	292.9	291.5	314.8	268.2	286.0	316.5	246.9	0.5	7.9	1.9

Source: Computed from actual price data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

^a The text explains how this target is arrived at.

^b The difference between target and actual ceiling prices is expressed as a percentage of the target ceiling price.

^c The difference between the target and actual floor prices is expressed as a percentage of the target floor price.

^d The difference between the actual and target annual prices is expressed as a percentage of the actual price.

The nature of the price fluctuation between the proposed and the existing modes of stabilization is examined in Table 19. If the proposed mode of stabilization had been operative during 1976-84, the fluctuation in annual prices would have varied from 3.4 to 23.1 percent, as compared with variations of -17.3 to 41.3 percent under the existing system. The proposed stabilization model allows some variation in annual prices but it contains severe fluctuations. Seasonal (or intrayear) fluctuations are also reduced under the proposed mode of stabilization. Seasonal prices vary by a stable 15 percent every year in the proposed model compared with variations from a low of 13.8 percent in 1980/81 to a high of 37.8 percent in the following year under the existing system.

What are the implications for policy instruments associated with the two modes of stabilization? The comparison of actual public procurement and distribution figures and those that would have been required under the proposed procedure are shown in Table 20. The simulated procurement and distribution figures in the table were derived by examining monthly prices. If the actual ceiling price in a particular month is above the ceiling price, then the quantity required to bring down the actual to the target ceiling price is estimated using equation (30). All monthly requirements are added to arrive at the incremental quantity of open market sales that the government should have undertaken. These quantities are shown in column 3 of Table 20.

The incremental quantity that the government would have to procure over the amount acquired with the existing procedure to support the floor price is estimated following a similar month-by-month evaluation of prices. If the actual floor price is lower than the target floor price, then the additional quantity to be procured to bring up the actual to the target floor price is estimated using equation (30). All such monthly estimates are added to arrive at the total additional quantity of procurement. It must be noted that distribution and procurement are seasonal operations, but their estimates are based on equation (30), which is based on annual data. A complete model based on seasonal prices is not possible due to the data problems described in Chapter 5. It

Table 19—Actual variability in rice prices compared with variability under the proposed model, 1976/77-1984/85

Year	Proposed Model		Actual Figures	
	Fluctuation in Annual Price ^a	Fluctuation in Seasonal Price ^b	Fluctuation in Annual Price	Fluctuation in Seasonal Price
	(percent)			
1976/77	...	14.8	...	24.5
1977/78	18.7	14.8	26.4	16.7
1978/79	6.9	14.8	4.2	29.5
1979/80	23.1	14.8	41.3	21.9
1980/81	3.4	14.8	-17.5	13.8
1981/82	10.7	14.8	28.1	37.8
1982/83	9.7	14.8	10.8	17.7
1983/84	8.8	14.8	7.3	17.3
1984/85	17.1	14.8	11.2	22.0

Source: Actual fluctuation figures are computed from data provided by Bangladesh, Ministry of Agriculture, Department of Agricultural Marketing, Dhaka.

^a The fluctuation in annual prices is the difference in prices between years t_n and t_{n+1} measured as a percentage of the price in t_n .

^b The fluctuation in seasonal prices is the difference in the ceiling (Cn) and the floor (fn) prices measured as a percentage of Cn.

is hoped that this difference in method does not make a substantial difference in outcome. What it implies, however, is that actual operation of procurement and distribution activities has to be closely monitored, and these activities should be changed according to the actual response in ceiling and floor prices.

The tasks of procurement and distribution under the proposed procedure vis-à-vis the actual procedure can be examined, keeping the background explanation in mind. For both public open market sales and procurement, 1977/78 appears to be a year when the current procedure and the proposed model are almost the same. In 1976/77, as well as 1978/79 and 1980/81, procurement should have been larger than it was. There should have been no procurement in 1979/80 and procurement quantities

Table 20—Actual public distribution and procurement of foodgrains, 1976/77-1984/85, compared with quantities simulated by the model

Year	Public Distribution			Procurement from Domestic Production		
	Actual	Simulated	Difference	Actual	Simulated	Difference
	(1,000 metric tons)					
1976/77	1,216	1,266	50	313	680	367
1977/78	1,557	1,569	12	541	557	16
1978/79	1,483	1,570	87	317	580	263
1979/80	1,784	2,479	695	226	0	-226
1980/81	1,123	808	-315	841	1,390	549
1981/82	1,344	1,662	318	287	241	-46
1982/83	1,190	1,440	250	168	141	-27
1983/84	1,205	1,475	270	145	128	-17
1984/85	1,327	1,340	13	133	286	153

Source: Actual figures are from Bangladesh, Bureau of Statistics, *Statistical Yearbook, 1985* (Dhaka: BBS, 1986).

should have been smaller than they actually were in 1981/82 through 1984/85. This could have been accomplished by adjusting the procurement price as reflected in equation (24).

For public distribution, the sharpest departure of simulated from actual occurs in 1979/80. This was a semifamine year in Bangladesh when actual open market sales of an additional 695,000 tons could have prevented the price from going above the ceiling. On the other hand, public distribution of foodgrains in the following year, 1980/81, when crops were good, should have been about 800,000 tons instead of the actual distribution of 1.12 million tons. This could have been accomplished by adjusting the administered price downward in 1979/80 and upward in 1980/81 (equation 25).

Cost Implications

The higher the degree of price stabilization, the higher should be the cost to the public exchequer. It is this budgetary cost that is estimated here.

As discussed in Chapter 3, budgetary costs include the administrative costs, costs of the discretionary food subsidy meant for welfare of the poor, and the costs involved in maintaining foodgrain stocks. The cost estimates below relate to the cost of stock only for a number of reasons. First, stocking cost is by far the largest of the three components. Second, the administrative and discretionary subsidy costs can be treated as fixed costs. Only the stocking cost is implicated by the adoption of the new procedure for price stabilization; it does not impinge on the other two aspects of costs that are related to the existing program. Moreover, it is not feasible to disentangle the various elements of costs under the present program from those related to price stabilization and those directed to food subsidy objectives. Therefore, comparison of the costs involved in the proposed model with those of the existing model is made on the basis of current stocking costs vis-à-vis the stocking costs under the proposed system.

Thus the question becomes one of determining how much stock is maintained for the current system and how much will be required for the proposed system. It does not consider complications surrounding the issue of an "optimal stock," which is itself an important but controversial issue in Bangladesh. The stock maintained for running the current system is available year by year. The mean stock level of 1976/77-1984/85 is taken as the stock for the current system. Additional stock required for the proposed system is determined on the basis of how much is needed for the additional public sales and purchases necessary for implementing the proposed system. This estimate is roughly equivalent to the mean incremental public distribution (based on column 3 in Table 20) plus two standard deviations of the distribution. No additional stock is necessary for procurement operation. The estimated stock for public distribution will meet the needs for the first four to six months of a year and thereafter will be replenished from domestic procurement or imports or a combination of both. Thus, the estimate of incremental stock for the proposed model takes into account the opportunity for trade.

The estimated stocks and their costs shown in Table 21 indicate that public stock of foodgrains would have to increase by about 700,000 tons if the proposed system of price stabilization were adopted without reducing the current magnitude of the rationing program. In reality, the environment of stable market prices that the proposed system would bring about might reduce the pressure on ration distribution. In that event, the actual incremental cost for the proposed program would be smaller than the estimate shown in the table. Introduction of the proposed system implies a gradual transition from a system geared more to ration distribution to one oriented more to open market sales by government.

Table 21—Comparison of costs related to the current (1986/87) and the proposed systems of price stabilization

Price Bands ^a	Stock Required for the Cur- rent System	Incremental Stock Required for the Pro- posed System	Cost of Current System ^b	Incremental Cost for the Proposed System
	(1,000 metric tons)		(Tk million)	
4 percent band in annual prices and 8 percent band in seasonal prices ^c	668	700	541.1 (\$16.4)	567.0 (\$17.2)
4 percent band in annual prices and 10 percent band in seasonal prices	668	470	/ ...	380.7 (\$11.5)

^a The price band system is not applicable to the current system.

^b Cost estimates are based on Tk 5,400 per ton of rice and an interest rate of 15 percent per year. The figures in parentheses are U.S. dollar equivalents at the official exchange rate in 1986/87.

^c This price band and its related procurement and distribution figures are shown in Table 20.

The cost of the proposed system could be reduced further if the political tolerance to price instability could accept a wider price variation.

Operating Rules and Use of Policy Instruments

Price Targets and Stock

Planning for the next year's stabilization program should begin with the determination of a price target within the price band at the end of the current year. Although price-based planning of the food system would be a shift from the current practice of quantity planning, it would not mean that quantity targets would be abandoned, considering that budgetary planning cannot proceed without quantitative physical targets. Quantity targets are derived with some degree of consistency from the price targets.

Before deriving price targets, one should be sure that the price band is set correctly. In the initial phase of the shift from the existing to the proposed system, it is advisable to be cautious and to permit a price band to evolve over time that is optimal in the sense that it leaves no scope for sub- or supernormal profits in trading. A 4 percent band in annual prices and an 8 percent band in seasonal prices is appropriate to begin with because it is consistent with current frequencies of heightened interventions through open market sales and fluctuations in real prices. Such a price band is normal for traders in interyear stocking of foodgrains.¹¹

The selection of a target price and estimation of the predicted prices are clearly dependent on production and income estimates. As indicated earlier, estimates of effective production for aus and boro for the next year (say 1985/86) are available with certainty at the time of the annual planning exercise in 1984/85. Cereals forecasts of aman rice and wheat are available then. Even though some adjustment in target and predicted prices is possible as later forecasts come in, public stock plays a more crucial

¹¹ No recent empirical study is available to support this point, but a past study by Farouk (1970) and discussions with current traders lend credence to it.

role in adjustment than target or predicted prices because, even if better estimates are available in the later part of the year, it is too late for imports to be shipped and received in the same year. Thus, correctly estimating the variability of aman and wheat production is critical for determining the size of stock required for price stabilization.

Analysis of data for 1975-85 indicates that the maximum fall in production of aman and boro in any year was about 865,000 tons. A shortfall of 500,000-600,000 tons in aman production can be expected in 2 out of every 10 years. A 600,000-ton shortfall in rice is equivalent to a shortfall of 960,000 tons of foodgrains with 60 percent wheat and 40 percent rice for the purpose of stabilizing rice prices in Bangladesh.¹² Therefore, an opening stock of about 1 million tons of foodgrains appears to be a critical requirement for stabilization of prices.

Historically, the opening stock in public godowns averaged about 650,000 tons, but in certain years the opening stock was as low as 200,000 tons, which is considered to be of no effect when operational problems are taken into consideration. The physical capacity of public godowns to hold stock runs as high as 2 million tons. A stock of up to about 1 million tons is not likely to be constrained by administrative ability to manage it.

For price stabilization, it is better to err on the side of maintaining a too-large stock than to hold too small a stock, because the price forecast is difficult to make, and private stockholding may be greatly influenced by the level and stability of public stock. Although no treatment of private stock is included in this analysis, it nevertheless influences market price, mainly because information on private stock is seldom available. Empirical evidence on the relation between private and public stock is rare. A study in Indonesia has shown that private traders' speculative behavior is extensively molded by the ability of government to act in markets (Siamwalla 1987). This ability is generally reflected in the level of public stocks. A recent survey indicates a similar behavioral response among rice traders in Bangladesh. This survey, which attempts to make a qualitative assessment of factors relating to stocking decisions of traders, shows that none of the ration variables such as ration price, quota, or offtake enter into stocking decisions of rice traders. On the other hand, more than 90 percent of traders in both wholesale and retail groups consider open-market sales of foodgrains by the government an important factor in their stocking decisions (BECON 1986, Shahabuddin 1987). Of course, the ability of the government to conduct effective open market sales, particularly during the October-November peak price season, depends greatly on opening stock.

Imports and Public Distribution

Imports and public distribution are intimately connected in the food policies of Bangladesh. The determinants of imports have been examined previously (see Appendix 2, Table 25 for results of regressions with import data). This analysis shows that shortfalls in domestic production and availability of food aid are the principal determinants of imports. There are various other political and vested interests often considered as factors of inducements to import, but no basis exists to describe, much less to quantify, these speculative efforts.

Shortfalls in domestic production are central to determining the required volume of imports. As shown in Chapter 5, assessments of production loss due to natural

¹² It has been found, on the basis of price relations between rice and wheat, that the influence on market price of rice from the increase of market supply of one unit of rice, all else being equal, is equivalent to the same influence from the increase in wheat supply by 1.6 units (Ahmed 1979). This factor is used to convert rice into wheat equivalents.

calamities tend to be overstated during floods and understated during drought. Also, private stock, an unknown quantity, may have a tendency to decline sharply following sequential repetitions of natural calamities. Therefore, natural calamity, if it occurs repeatedly, may affect supply and prices more seriously than would be indicated by the sum of crop damages from sequential natural calamities. These considerations warrant a careful monitoring of crop production and forecasts.

Income has a more important effect on demand for foodgrains and hence on their prices in Bangladesh than in developed or many other developing countries. Estimates of income should be based on the gross national product (GNP) rather than on the gross domestic product (GDP). In this analysis the relationship with GDP as the measure of income was inconsistent. GNP per capita has increased faster than GDP per capita since 1977/78, implying an increase in the contribution of the external accounts to the economy of Bangladesh. The effects of income as well as price levels, given the target price for stabilization, should be taken into consideration in estimating the import target. The current practice of estimating the consumption requirement at the rate of 16 ounces of rice per capita per day should be revised to include income and price effects.

Internal Procurement

The first estimate of the target of procurement is derived from the difference in the price target and the predicted prices elaborated in Tables 18 and 20. This estimate, based on the annual aggregate, is only a rough approximation, however, because procurement is largely a seasonal activity influenced by various seasonal and regional diversities. It will require fine-tuning based on up-to-date knowledge of regional diversities, if possible.

The need for flexibility in the procurement program arises from another reason alluded to earlier. Seasonal prices are often influenced by erratic behavior of factors that are hard to identify. The stock decisions of private traders, including large farmers, are dominant among them. Generally, when a good crop follows a bad crop, the harvest season fall in price is not as sharp as when a good crop follows two successive bad crop seasons. Similarly, election year expenditures or other sudden spurts in public expenditures may induce unpredictable pressure on the demand side, which may cause harvest and peak season prices to deviate from normal patterns. Some degree of flexibility in both procurement and open market sales programs is necessary to counter these erratic influences.

CONCLUSIONS

More than 100 million people live in Bangladesh, and the country is known worldwide for its extreme poverty. With no room for extension of cultivated land, the increasing pressure of population has resulted in fragmentation of farms into smaller and smaller units and created a tremendous need for expansion of nonagricultural employment. The number of households depending on markets for supply of foodgrains has been increasing rapidly. Rice is the dominant foodgrain in the diet of the population; thus stability of rice prices is critical to social stability in Bangladesh. Because of the influence of rice prices on prices of jute and other cash crops, stability in the rice market implies a stable environment that is necessary not only for growth of agriculture but growth of the entire economy. A modest success in adoption of modern technology in agriculture has been found to coincide with a greater degree of variability in rice prices in recent years.

No government in Bangladesh can afford to keep aloof from the happenings in the foodgrain sector. But intervention in foodgrain markets involves costs in resources that are required for long-term programs to eradicate poverty. Therefore, government intervention is required for efficiency, and it is limited to the containment of extreme fluctuation of prices and supply. In the past, the government primarily depended on the rationing system to keep prices from rising abnormally. In recent years, the government has used ration distribution, open market sales, and postharvest procurement for stabilizing prices. Application of these policy instruments is based on targets of quantities to be distributed, imported, and procured from domestic production. In the absence of a consistent approach based on price instead of quantity targets, the government's efforts have been relatively ineffective and wasteful.

The framework for stabilization of rice prices in Bangladesh accommodates operations of private traders as principal actors in consonance with a complementary public intervention in foodgrain markets. The framework and operational principles stipulated here may seem cumbersome to those who are generally reluctant to make a change in the management of Bangladesh's food sector. But the procedure is in fact relatively simple. As mentioned earlier, the current system is relatively ineffective in maintaining stability in market prices, and the urgency of continuing the rationing system is also likely to diminish once a stable price environment is established. The existing Food Monitoring Unit (FMU) under the Ministry of Food can provide the institutional basis for application of the framework. A small amount of investment to upgrade the skill and professional strength of FMU will enable it not only to adopt the framework as developed here but also to improve upon it as new experience is gained through its application.

APPENDIX 1:

THE CENSUS X-11 PROCEDURE

The Census X-11 procedure is a Fortran-based program for decomposition of time-series data into component parts. The basic steps for computing each iteration of estimates of the seasonal (S), irregular (I), and trend (T) factors are listed below. The procedure executes three iterations to stabilize the irregular and seasonal components.

1. NP = nominal price series,
2. T1 = 2×12 -term moving average of NP (first trend estimate),
3. SI1 = NP/T1 (first seasonal, irregular estimate),
4. S1 = 3×5 -term moving average of SI1 (first seasonal estimate),
5. End points are filled in,
6. I1 = SI1/S1 (first irregular estimate),
7. SI1a = weighted SI1 (observations more than two standard deviations from the mean are given 0 weights),
8. S2 = five-term moving average of SI1a for each month (second seasonal estimate),
9. SA1 = NP/S2 (first estimate of seasonally adjusted series), and
10. T2 = 13-term moving average of SA1 (second trend estimate).

For two more iterations, use NP and T2 to redo steps 3 to 10.



APPENDIX 2: SUPPLEMENTARY TABLES

Table 22—Integration of nominal prices into trend, seasonal, and irregular factors, 1960 and 1984

Year	Month	NP	=	T	×	S	×	I
1960	1	21.69		24.21		0.9068		0.9879
1960	2	23.79		25.03		0.9391		1.0121
1960	3	24.42		25.90		0.9505		0.9920
1960	4	26.47		26.80		0.9874		1.0005
1960	5	27.83		27.65		1.0147		0.9918
1960	6	29.97		28.08		1.0466		1.0196
1960	7	30.33		27.87		1.0782		1.0095
1960	8	28.41		26.99		1.0447		1.0076
1960	9	25.59		25.81		1.0064		0.9850
1960	10	24.65		24.72		1.0042		0.9929
1960	11	21.98		24.02		1.0289		0.8893
1960	12	23.56		23.78		0.9916		0.9990
1984	1	246.90		258.72		0.9329		1.0230
1984	2	264.80		260.48		0.9915		1.0253
1984	3	264.25		260.85		1.0319		0.9817
1984	4	280.20		261.86		1.0741		0.9962
1984	5	286.60		268.08		1.0723		0.9970
1984	6	282.80		281.69		1.0231		0.9812
1984	7	286.00		297.69		0.9563		1.0046
1984	8	302.00		308.49		0.9580		1.0218
1984	9	296.00		311.49		0.9364		1.0148
1984	10	313.00		309.74		1.0171		0.9935
1984	11	305.00		307.98		1.0247		0.9664
1984	12	310.00		306.73		0.9814		1.0298

Notes: NP is nominal price, T is the trend factor, S is the seasonal factor, and I is the irregular factor.

Table 23—Correlation coefficients of interdistrict aus rice prices, 1976-82

District	2	3	4	5	6	7	8	9	10
Barisal (2)	1.000	0.925	0.849	0.918	0.987*	0.996*	0.994*	0.976*	
Bogra (3)		1.000	0.884	0.955*	0.901	0.915	0.906	0.875	
Chittagong (4)			1.000	0.979	0.835*	0.884	0.874	0.906	
Chittagong Hill Tract (5)				1.000	0.909	0.935*	0.929	0.934*	
Comilla (6)					1.000	0.984*	0.992*	0.971*	
Dhaka (7)						1.000	0.998*	0.992*	
Dinajpur (8)							1.000	0.991*	
Faridpur (9)								1.000	
Jessore (10)	0.987*	0.947*	0.992	0.967*	0.969*	0.993*	0.988*	0.983	1.000
Khulna (11)	0.996*	0.922	0.869	0.932	0.995*	0.996*	0.998*	0.983*	
Kishoregarij (12)	0.972*	0.920*	0.821	0.905*	0.997	0.982*	0.988*	0.955*	
Kushtia (13)	0.972*	0.920	0.820	0.905	0.997*	0.981*	0.987*	0.959*	
Mymensingh (14)	0.979*	0.947*	0.784	0.882	0.953*	0.958*	0.953*	0.912	
Noakhali (15)	0.996*	0.924	0.873	0.932	0.988*	0.988*	0.988*	0.985	
Pabna (16)	0.980*	0.922	0.927	0.958*	0.957*	0.992*	0.985*	0.989*	
Patuakhali (17)	0.989*	0.958*	0.914	0.965*	0.972*	0.992*	0.987*	0.977*	
Rajshahi (18)	0.925	0.999*	0.871	0.950	0.907	0.912	0.907	0.871	
Rangpur (19)	0.967*	0.970*	0.820*	0.918	0.964*	0.949*	0.951*	0.908	
Sylhet (20)	0.972*	0.986*	0.889	0.957*	0.944*	0.965*	0.957*	0.933	0.982*
Tangail (21)	0.986*	0.975*	0.868	0.944*	0.967*	0.976*	0.972*	0.944	0.984*

Table 24—Correlation coefficients of interdistrict aman rice prices, 1976-82

District	2	3	4	5	6	7	8	9	10
Barisal (2)	1.000	0.965*	0.653	0.734	0.608	0.578	0.975*	0.546	0.813
Bogra (3)		1.000	0.812	0.869	0.780	0.758	0.909*	0.724	0.933*
Chittagong (4)			1.000	0.993*	0.995*	0.991*	0.496*	0.930*	0.960*
Chittagong Hill Tract (5)				1.000	0.983*	0.975*	0.587	0.922*	0.981*
Comilla (6)					1.000	0.999*	0.451*	0.937*	0.941*
Dhaka (7)						1.000	0.420	0.934*	0.941*
Dinajpur (8)							1.000	0.400	0.701
Faridpur (9)								1.000	0.400
Jessore (10)									1.000
Khulna (11)	0.857	0.958*	0.935*	0.964*	0.922*	0.909*	0.758	0.845	0.996
Kishoregarij (12)	0.779	0.907*	0.978*	0.993*	0.971*	0.961*	0.652	0.898*	0.996*
Kushtia (13)	0.781	0.910*	0.976*	0.990*	0.968*	0.960*	0.657*	0.891*	0.997*
Mymensingh (14)	0.832	0.939*	0.962*	0.985*	0.946*	0.934*	0.713	0.870	0.997
Noakhali (15)	0.649	0.811	0.999*	0.992*	0.997*	0.994*	0.494*	0.943*	0.963*
Pabna (16)	0.672	0.832	0.991*	0.986*	0.991*	0.994*	0.494	0.943*	0.963*
Patuakhali (17)	0.999*	0.969*	0.656	0.735	0.611	0.582	0.977*	0.562	0.818
Rajshahi (18)	0.908*	0.983*	0.880*	0.926*	0.864	0.845	0.833	0.814	0.974
Rangpur (19)	0.877	0.969*	0.892*	0.932*	0.884*	0.869	0.801	0.818	0.982*
Sylhet (20)	0.684	0.841	0.989*	0.990*	0.993*	0.987	0.545	0.932*	0.978
Tangail (21)	0.586	0.760	0.994*	0.976*	0.996*	0.997*	0.422	0.917*	0.939

11	12	13	14	15	16	17	18	19	20	21
0.998	0.991	0.970	0.955	0.992	0.996	0.999	0.943	0.995		
1.000	0.984*	0.994*	0.963*	0.998*	0.979*	0.989*	0.924*	0.966*		
	1.000	0.979*	0.984*	0.988*	0.978*	0.995*	0.969*	0.982*		
		1.000	0.974*	0.989*	0.954*	0.975*	0.927*	0.980*		
			1.000	0.969*	0.937*	0.965*	0.940*	0.982*		
				1.000	0.987*	0.993*	0.923*	0.961*		
					1.000	0.993*	0.914	0.927		
						1.000	0.952*	0.965*		
							1.000	0.977*		
0.965*	0.996*	0.950*	0.978*	0.971*	0.967*	0.988*	0.983*	0.979*	1.000	0.996*
0.980*	0.999*	0.980*	0.988*	0.983*	0.968*	0.990*	0.975*	0.989		1.000

* This number is significant at the 0.01 level.

11	12	13	14	15	16	17	18	19	20
1.000	0.987*	0.989*	0.995*	0.937	0.954*	0.861	0.987*	0.992*	0.957*
	1.000	0.999*	0.995*	0.978*	0.985*	0.782	0.957*	0.966*	0.990*
		1.000	0.996*	0.977*	0.987*	0.784	0.956*	0.967*	0.971*
			1.000	0.960*	0.969*	0.833	0.972*	0.976*	0.971
				1.000	0.993*	0.652	0.897*	0.919*	0.992*
					1.000	0.674	0.890*	0.919*	0.992*
						1.000	0.916*	0.886*	0.690
							1.000	0.996*	0.915*
								1.000	0.930*
									1.000
0.908*	0.960*	0.960*	0.936	0.993*	0.991*	0.585	0.839	0.861	0.981*

*This number is significant at the 0.01 level.

Table 25—Estimates for rice markets using the simultaneous system of equations, 1960-84

Equations and Variables	Coefficients	t-Ratio
Demand equation (22)		
Constant	185.99	11.11
Y_{t-1}	-	0.79
PR_t	-1.61	-3.25
SW_t	-4.21	-5.13
Procurement equation (24)		
Constant	-1.11	-0.16
QR_t	-0.02	-0.92
ADP_t	0.38	1.33
OS_t	0.38	0.75
PR_t	-0.16	-0.79
Public distribution equation (25)		
Constant	-3.63	-0.48
PR_t	0.09	0.52
$ADPR_t$	0.06	0.36
Z_t	0.66	3.80
Import equation (28)		
Constant	10.34	5.65
GAP	0.00	2.36
FA	0.01	4.57
WP	-0.03	-0.28

Table 26—Selected data for 1976-84 used in the analysis of rice price stabilization

Year	Nominal Price of Rice	Deflated Price of Rice	Weighted Ration Price	Deflated Ration Price	Procurement Price	Deflated Procurement Price
				(Tk/maund)		
1976	110.02	28.07	80.60	20.56	120.0	30.61
1977	139.00	32.18	77.20	17.87	134.0	31.02
1978	144.92	32.28	87.30	19.44	136.0	30.29
1979	204.71	37.63	98.70	18.14	165.0	30.33
1980	168.86	27.91	115.50	19.09	170.0	28.10
1981	216.31	32.38	137.70	20.61	191.0	28.59
1982	239.61	32.34	154.30	20.82	210.0	28.34
1983	257.23	32.64	168.70	21.41	225.0	28.55
1984	286.00	33.49	170.50	19.96	248.0	29.04

Year	Rice Production	Wheat Production	Opening Stock of Rice	Rice Imports	Public Distribution	Procurement of Rice	Previous Year's GNP	F.O.B. Price	GNP in Real Terms
			(1,000 metric tons)				(Tk million)	(US\$/ton)	(Tk million)
1976	13,003	203	800	819	1,216	313	107,602	220.40	29,724.3
1977	12,549	308	373	1,634	1,557	541	105,816	247.85	25,935.3
1978	13,553	438	597	1,134	1,483	317	131,516	311.80	29,487.9
1979	12,250	728	209	2,979	1,784	226	146,610	339.95	28,917.2
1980	14,292	968	791	1,059	1,123	841	178,337	278.09	33,025.3
1981	14,140	857	1,239	1,229	1,344	287	201,849	301.14	33,144.3
1982	14,181	970	578	1,844	1,190	168	225,886	242.25	35,130.1
1983	15,265	1,073	793	2,135	1,205	145	263,721	175.00	35,304.0
1984	14,473	1,296	631	2,575	1,327	133	304,250	171.00	34,771.4

Source: Bangladesh, Bureau of Statistics, *Yearbook of Statistics*, various issues.

Note: Prices are for the coarse variety of rice.

APPENDIX 3: MODIFICATIONS NECESSARY FOR APPLICATION OF THE PROCEDURE FOR SELECTION OF TARGET PRICES IN FUTURE YEARS AND FOR ADJUSTMENT TO LONG-RUN PRICE MANAGEMENT

This supplement aims to clarify two points: (1) What changes in estimation of normal or trend prices are necessary for the selection of target prices after 1984/85? (2) What procedure is appropriate to make the short-run stabilization procedure described in this paper consistent with any future need to realign rice prices in a desirable long-run direction?

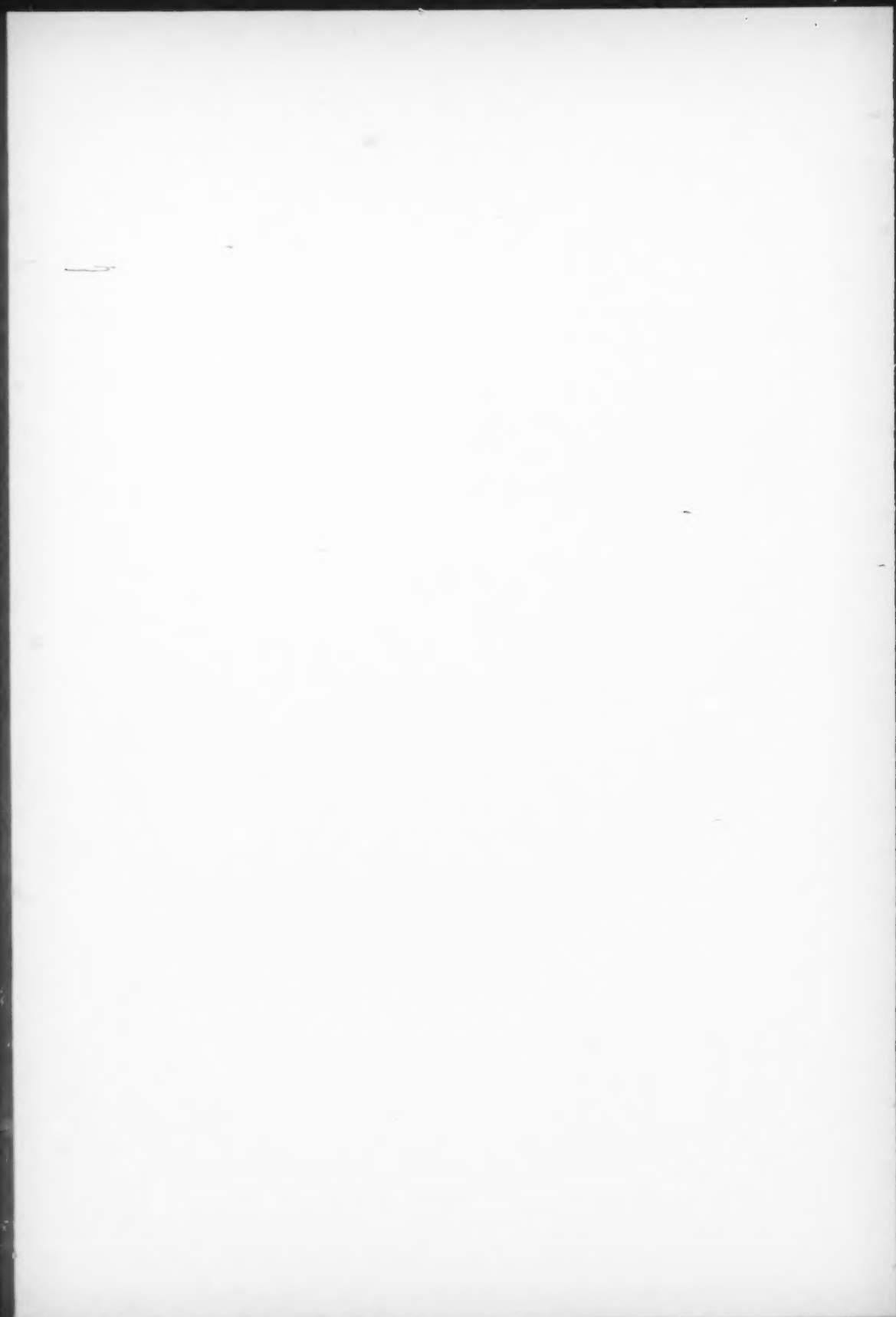
Although the hypothetical case described below is not applicable to Bangladesh, where domestic prices are slightly higher than the world price even assuming a 25 percent overvaluation of Bangladesh's exchange rate, the procedure is described here for those who wish to adapt the methodology to other country situations.

Modification for Future Target Prices

In the simulation for 1976/77-1984/85 a trend line estimate of prices is used based on 1968/69-1984/85 price series (excluding crisis years of 1973/74 and 1974/75). For future years, say for 1985/86, the extrapolation of the trend would provide the normal price for that year. But for 1986/87, the trend should be reestimated by dropping 1968/69 and including 1985/86—the latest year of available data. This trend then would be extrapolated for 1986/87. For each coming year thereafter, the trend line should be reestimated, dropping one year at the beginning and including the latest year at the end of the price series.

Modification for Adjusting Prices for the Long Run

It is clear from the discussion that the concept of "normal price" has been adopted here as a reference for selection of the target annual price by comparing it with the predicted price. If this normal price is judged to be very low in comparison with, say, world price, due to accumulated past distortions, what changes in the procedure are necessary to allow the correction of this past distortion through the selection of annual target prices? Suppose that in year 1984/85 the normal price is lower than the world price (or the long-run desirable level of rice price) by 15 percent, and it is decided that this distortion should be corrected in three consecutive years, for example in 1985/86, 1986/87, and 1987/88. Assuming that this distribution of accumulated distortions implies an increase of Tk 15 per maund each year over the initial target annual prices based on trend and predicted prices, the final target annual price would then be equal to each initial estimate of target annual price plus Tk 15. This upward adjustment in target prices would of course imply a larger volume of procurement and a smaller volume of public distribution and imports than would be the case without the adjustment to world prices, unless import and administered prices are also adjusted in a consistent manner. Adjustment in import and administered prices also implies a change in predicted price.



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NONTRADITIONAL EXPORT CROPS IN GUATEMALA: EFFECTS ON PRODUCTION, INCOME, AND NUTRITION

Joachim von Braun
David Hotchkiss
Maarten Inmink

May 1989

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Maarten Immink**

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in collaboration with the
Institute of Nutrition of Central America and Panama
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FOREWORD

Modernization of traditional agriculture entails increased participation of the smallholder sector in the exchange economy. The achievement of this participation requires an open trade regime, domestic policies that ensure against market failures, and public policy that effectively permits use of new production technology for sustained growth. To open up these opportunities to small farmers, investment in rural infrastructure is essential, as is investment in education that will enable these farmers to participate as entrepreneurs in the growth process. In order to reach out to the landless and land-scarce households, the growth process must stimulate employment and increased returns to land. Nontraditional vegetables for export have a high labor content and therefore promise to help foster rural modernization.

In this study of nontraditional export crops and traditional smallholder agriculture in Guatemala, Joachim von Braun, David Hotchkiss, and Maarten Immink highlight the potentials and risks of export orientation in smallholder agriculture for food security. The policy implications of the report reach far beyond the study area in Central America. The multidisciplinary team of IFPRI and the Institute of Nutrition of Central America and Panama (INCAP) has gone far toward tracing the critical linkages between economic development and nutritional improvement. Two lessons of the study are of critical importance for policy. First, growth in staple food production, stimulated jointly with diversification into nontraditional crops, is necessary to actually capture the gains from specialization in typically risky market environments. Second, joint operation and development of the health and sanitation infrastructure in rural areas is required in order to translate the growth effects into nutritional welfare effects for the poor.

This study, which is a component of IFPRI's ongoing research effort in the field of commercialization of agriculture for food security and poverty alleviation, provides evidence that the income and employment effects of cash cropping can be considerable and, if accompanied by appropriate public policy, can make a major contribution to eliminating hunger and malnutrition.

John W. Mellor

Washington, D.C.
May 1989

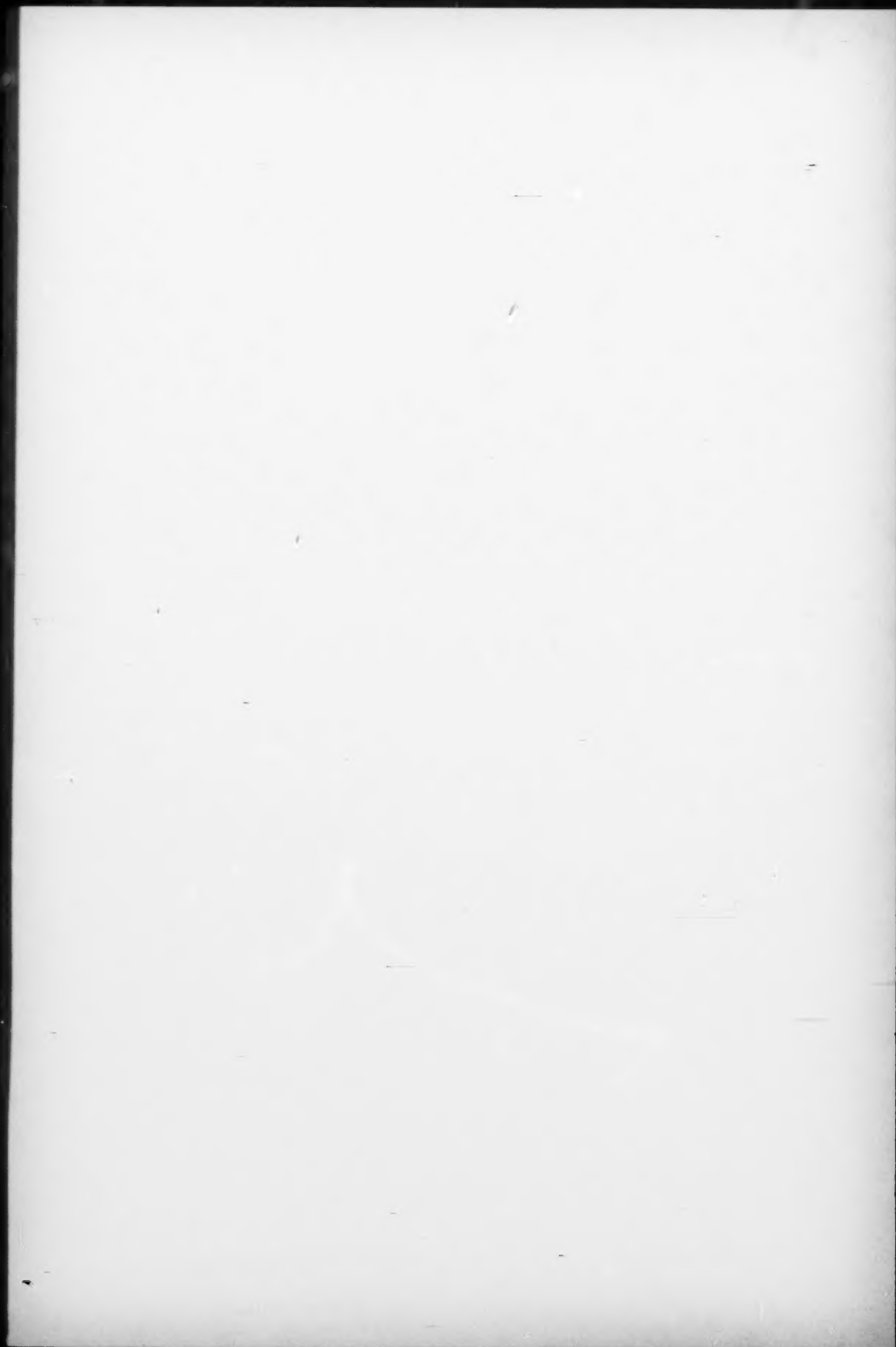
IN MEMORIAM—VICTOR VALVERDE

This research project was jointly designed and its first phase jointly directed with Victor Valverde of INCAP, whose unexpected death in June 1986 came as a shock to his friends and colleagues. This project is one of many research activities stimulated by Victor to improve the understanding of poor people's living conditions and especially of their nutritional situation.

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This research project is based on complex sample surveys whose successful execution was made possible by the patient respondents in six Guatemalan villages and careful enumerators under the experienced supervision of INCAP. Mireya Palmieri was instrumental in the design and execution of the survey work. Local support of the research by the Cuatro Pinos cooperative, and in particular by its executive manager, Tulio García, was essential for appropriate implementation of the research and interpretation of results.

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SUMMARY

Increasing foreign exchange problems and deteriorating prices of traditional export commodities are leading agricultural policymakers to seek diversification in export crop production. Export vegetables, which are nontraditional crops, appear to be a promising option because of their high labor intensity and expanding demand in industrialized countries. This study deals with a case of export vegetable production and its effects on food production, employment, consumption, and nutrition in Guatemala.

Guatemala's agriculture has shifted away from food production to agroindustrial crops. Food crops covered 58 percent of the country's crop area in 1950 compared with 37 percent in 1979. Small farms decreased their basic food crop area from 97 percent to 87 percent in this period.

The focus of this study is the recent introduction of labor-intensive production of vegetables for export in the traditional small-farm sector in the Western Highlands—an area well known for its problems of poverty and malnutrition. Besides considerable research on the "cash cropping-nutrition" issue, the study provides both cross-sectional and longitudinal analyses of effects. The research is based upon two detailed rural household surveys (400 families) that were undertaken in 1983 and 1985. The sample is divided into two groups of households—those who produce the new export vegetables (snow peas, broccoli, cauliflower, and parsley) under a cooperative scheme and those who do not. Differences in duration of participation (one to seven years) in the export crop scheme—the Cuatro Pinos cooperative—characterize the subsample of the export crop growers.

The new export vegetables were rapidly adopted by the smallest farmers (average 0.7 hectare). The model analysis in the study shows that in the early phase of adoption, small farmers with somewhat larger holdings (1-2 hectares) and households that had no reasonably well secured off-farm income source showed a significantly higher probability of adoption. Access to good roads and infrastructure also increased adoption rates.

The new vegetables have certain risks for the small farmers due to possible crop failures, price collapses on the export market, or a breakdown of the marketing institutions. Relative production variability of the new crops is not higher than in the traditional crops, but because the new crops are much more input-intensive the potential loss relative to household income is higher than for the traditional crops. The price variability of the new crops—especially of snow peas, the most important one of them—is extreme. In 1985, prices fluctuated between 0.10 and 2.00 quetzals per pound, but farmers can partially cope with this variability by spreading the growing seasons and having a long harvest period (12 weeks). Recently, in addition to a multinational company and the cooperative, other traders have handled the export channel. Also, local processing and freezing of fresh produce have been initiated. These developments reduce the risk of a sudden collapse of the marketing channel.

Nontraditional export crops are substantially more profitable to farmers than traditional crops. Net returns (gross margins) per unit of land of snow peas are on average 15 times those of maize—the most important traditional crop. Returns of the new crops per unit of family labor were about twice as high as for maize and 60 percent higher than for traditional vegetables produced for local markets in 1985. The input costs per hectare for snow peas, however, are on average about 4 times higher than

for traditional vegetables and 13 times higher than for maize. Short-term financing of inputs poses a problem to small farmers and indicates the importance of rural credit.

Farm households outside the cooperative grow traditional subsistence crops (maize and beans) on 78 percent of their land, whereas participants in the scheme grow those crops on 52 percent of their land. The smallest cooperative farms allocate the highest shares of land to the new export crops.

Nevertheless, most export crop producers tend to have higher amounts of maize available (per capita) for consumption from own produce than other farmers of the same farm size, because cooperative members' maize and bean yields are 30 percent higher on average than nonmembers' yields. A combination of factors is responsible for this increase in yields; fertilizer inputs are increased and cropping practices are more labor-intensive (more weeding labor). Farmers with the most school education were found to have even higher yields at given input levels.

Analysis with the help of a consistent farm household model based on the survey data shows that with new export crops the shadow cost of maize produced for own consumption increased drastically. The difference between the shadow cost and the actual market price (0.29 quetzal in 1985) may be interpreted as an "insurance premium" that farmers are willing to pay for the degree of self-sufficiency they actually maintain.

Nontraditional export crops created local employment directly on farms and indirectly through forward and backward linkages and multiplier effects resulting from increased income spent locally. Combining farm-level employment with the roughly estimated employment created through the input supply and output marketing yields an overall 21 percent increase in agricultural employment in the six communities where the cooperative functions. Labor input in agriculture increased by 45 percent on the farms producing export vegetables. About half of this increase is due to family labor and half to hired labor. A substantial share of the incremental increase in family labor is from women and children. As a consequence of increased on-farm employment, off-farm work and interregional migration of members of export vegetable producers' households are found to be reduced.

The export crop production scheme led to increased income in the participants' households. This increase between the two surveys (1983-1985) was most pronounced in the group of new adopters, in which expenditures—used as an income proxy—increased by 33 percent. The income gains were highest among the adopters on the smallest farms, thus the new export crops had a favorable effect of moving the poorest upward on the income scale.

At same-income levels, export crop-producing farm households spend less of their additional income on food than traditional-crop households. While nonmembers in the lowest quartile on the income scale spend 61 percent of additional income on food, cooperative members in the same income class spend 53 percent. Additional income increases calorie acquisition significantly but at decreasing rates at the margin. Member households in the lowest half of the income scale increase their calorie consumption by 2.8 percent with a 10 percent increase in income, while nonmember households increase theirs by 4.4 percent.

The production- and income-related analysis concluded with favorable effects of the nontraditional crops for food crop productivity, employment, income growth, and income distribution. The expenditure and food consumption analysis found that incremental income earned from the nontraditional crops tends—at same-income levels—to be spent relatively less on food than other income; this is also reflected, although to a lesser extent, in calorie availability. Thus, food expenditures and consumption increased relatively less than expected. Improvement in the nutritional status of children,

most significantly in decreased wasting, is associated with increased income and food consumption in export crop-producing households. The nutritional benefits of economic growth, as shown in this study, are substantial but can be further enhanced by appropriate health- and nutrition-oriented social infrastructure. The effects of health programs conducted by the export crop cooperative in participating communities support this conclusion.

Especially in the late 1970s and early 1980s, steps to alleviate poverty and improve living conditions in Guatemala were constrained by the economic and political environment. The case study shows, however, that with appropriate access to resources and markets and effective assistance in institution-building at the community level, the poor in the Western Highlands can substantially improve their income and welfare.

THE RESEARCH ISSUES AND APPROACH

Commercialization of Traditional Agriculture

An increasing number of low-income countries are facing crucial strategic decisions on how to cope with short- and long-run food security problems. At the core of these strategic decisions is the appropriate choice of policies to promote production of export crops, cash crops for the domestic market (food and nonfood), and subsistence food crops.

Many developing countries are encouraging the increased production of export crops as a way to generate foreign-exchange earnings and fiscal revenues, to increase the income of small landholders, and to provide employment for the rural poor. However, critics of policies that advocate cash crop production argue that the potential benefits have never materialized and, more important, that in areas where cash crop production has increased, food consumption and the nutritional status of the poorest households have deteriorated. A comprehensive review of the existing literature and earlier research on the issue shows mixed results (Braun and Kennedy 1986). This is not surprising, given the great variety of cash crops and production conditions in general.

In developing countries, increased market integration of semisubsistence agriculture appears unavoidable. Rapid urbanization, growth of the rural nonagricultural sector, and technological change in agricultural production are the major driving forces of this commercialization process. Urbanization without increased rural-urban market integration would lead to volatile dualistic structures and import dependence.

On the basis of existing research, it is evident that critical relationships that determine food consumption and nutrition are affected by increased commercialization. These effects may be positive or negative. At the macroeconomic level, an issue of concern is whether foreign exchange generated through export cropping is actually used for imports of goods and services that improve the food consumption and nutritional situation of the poor. Foreign-exchange regulations and taxation of export crops, along with import controls by governments, may lead to distortions that prevent the poor, including small farmers in the export sector and other rural households, from having access to the direct and indirect benefits of the specialization.

This study concentrates mainly on the household-level effects of cash cropping in rural areas. At this micro level the outcome depends on changes in real income, income distribution, income composition, and income control (by men or women). How do these factors translate into household food consumption? What are the effects on time allocation (especially for mothers), and on health and sanitary factors? At this point, no clear ranking of factors is possible on the basis of existing research. A number of studies show, however, that the positive effect of increased cash income on calorie consumption may be quite small, even among the poor.¹ This may be a result of changes in income composition and income control within the household.

A crucial question for policy and program design is whether potential adverse effects of increased cash cropping on nutrition are actually observed and, if so, whether they are of a short- or long-term nature. This is not to say that short-term effects for one to

¹ See the review in von Braun and Kennedy 1986, 55-59.

two years should not be an issue of concern. But appropriate and efficient policy measures to balance potential adverse effects are dependent on the time frame of the problem. Whereas short-term problems may be dealt with mainly by adjustments in the timing of project implementation and a combination of measures such as temporary income support, price subsidies, and nutrition education, long-term adverse effects require very different policy instruments that have the potential to improve and stabilize living conditions for the losers in the commercialization process. Employment generation in rural areas would be a major element of these policies.

The uneasiness about the above-mentioned critical relationships between agricultural production and nutrition in the commercialization process suggested a series of detailed studies that are being executed at IFPRI in collaboration with other institutions.

Theoretical Approach and Concept

This study on the commercialization of smallholder agriculture in Guatemala looks into the introduction of nontraditional vegetables for export. It was clear at the outset that this change had substantial effects on agricultural production and employment in the study area. The order of magnitude of these effects and the effects on income, consumption, and nutrition, however, were not clear at all. The precise concern was that expansion of a crop for export in an area with a well-known nutrition problem might have adverse effects on the availability and security of food and might further aggravate the nutrition problem. If the export crop scheme increased employment and income of the poor, a related issue that stimulated the research was the provision of background understanding needed to ensure rapid translation of income growth into improved physical welfare, especially nutrition, in the households.

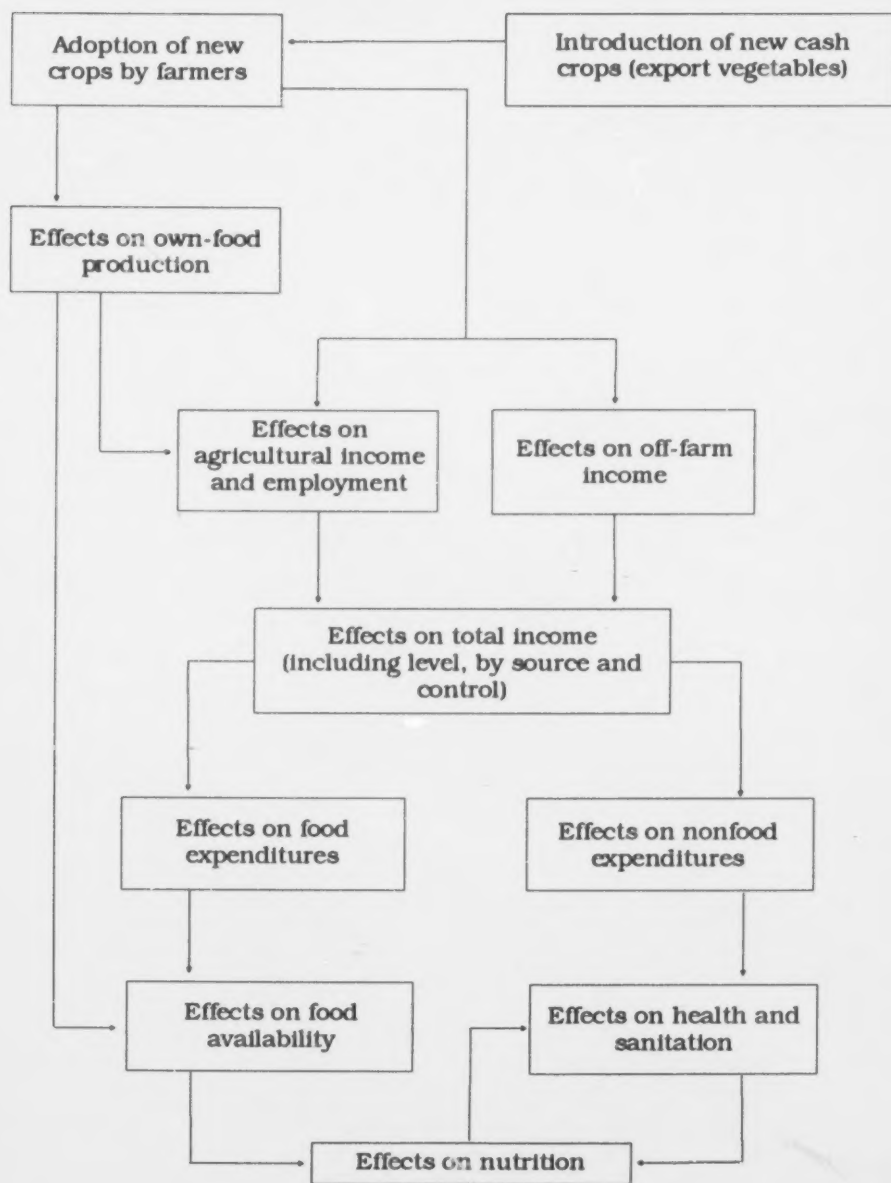
The theoretical concept of the household-level analysis of commercialization effects takes a disaggregated approach to tracing the consequences for different types of households and different groups inside the households. It is not *a priori* assumed here that incremental employment and income from the new crops leaves household utility functions unchanged. It is now widely recognized that farm households are not necessarily homogeneous units of decisionmaking.² Profound changes in the opportunities for income earning on the farm—be it through new technology or new market outlets—may have profound implications for division of labor and for relative control of income shares, which may change budget allocations within the household beyond the pure income effect. This study attempts to trace such effects and to quantify their impact on the consumption and nutrition effects of increased commercialization of traditional agriculture. Understanding these relationships is crucial to identifying policy options that avoid adverse effects of commercialization on consumption and nutrition in poor households and enhance positive ones.

The research focuses on the effects of the commercialization process on household-level food security. Food security, in this context, is understood in the broad sense as the ability of households and their members to acquire sufficient quantities of food over time, whether from own produce or from the market. Related to this, the effects of change in commercialization on the actual nutritional situation of children is assessed. The main relationships studied in this evaluation of increased commercialization are its effects on agricultural production (especially food) and on employment and income (on-farm, off-farm), and the extent to which these translate into effects on food and

² See Folbre 1986 and the literature quoted therein.

nonfood expenditures, food consumption, and nutrition. Clearly, these issues are related to each other. A simplified overview of the relationships as affected by commercialization at the household level is provided in Figure 1. This figure also provides an overview of the steps of analysis but does not depict the complex dynamics involved.

Figure 1—Flow of analysis for evaluation of household-level effects of the commercialization process



Overview of the Report

The commercialization process at the micro farm-household level should be understood in the context of the macroeconomic environment and its political economy. A review of commercialization of Guatemala's agriculture is provided at the outset. The introduction of new cash crops is evaluated in its institutional context. This requires a focus on the actual making and operating of the commercialization process; success or failure of a program is largely determined in this sphere, which is much underresearched. Therefore, those who play a role in commercialization are examined before the household-level effects are evaluated.

At the farm-household level, the process and determinants of adoption of the new crops are evaluated. The main questions addressed are who are the (early) adopters and what are their characteristics? In the context of this case study, this leads directly into the issue of competition and complementarity between nontraditional and traditional crops, on-farm and off-farm labor supply, and division of labor in the households. How is food availability from own production affected? Where does the increased labor input on the farm stem from? Who in the household controls the incremental farm income?

From the income effects, the effects for household resource allocation to food and nonfood expenditures are traced. Special focus is on food expenditures and food (calorie) availability. What share of incremental expenditure in export crop-producing households versus other households at same-income levels is spent on food and what types of food? To what extent is food availability in terms of calories improved?

Finally, these effects are traced to the nutritional status of children in the households. How is nutritional status—measured in anthropometric terms (weight, height-for-age)—affected by changes in food availability and the health and sanitation environment of the households?

The study concludes with lessons for policy from this particular case and an attempt to identify generalizable findings.

Survey Methods and Data

The household-level data of this research are based on representative surveys undertaken in 1983 and 1985 in the six villages where the Cuatro Pinos cooperative was active. The sample is based on a census in the villages done in 1983 (INCAP 1985). A roughly equal number of members of the cooperative ($n = 195$)—that is, growers of the new export crops—and nonmembers ($n = 204$) were drawn at random by village from the census information. To ensure a reasonable coverage in the smaller villages, the sample was biased toward the four smallest communities among the six villages. This brings the sample closer to the prevailing village pattern in the Western Highlands. The proportional adjustments of the sample by village size led to a coverage of 38-75 percent of the cooperative members in each community (average, 47 percent) and 8-17 percent of nonmember households (average, 11 percent) in these communities (Table 1).

The same households were surveyed in 1983 and 1985. They were visited between November and January of 1983/84 and 1985/86. Conducting both surveys during the same time of the year avoids the seasonality effects that might disturb comparisons between the two rounds.³

³ Seasonality in food consumption, however, does not appear to be very pronounced in Guatemala. See Valverde et al. 1985b.

Table 1—Village-level information: sampling in 1983 and 1985

Category	San Matéo	El Rejón	Santa María Cauqué	Pacul	Pachali	Santiago	Total
Size of village (number of households, 1983)	195	180	445	95	141	1,250	2,306
Cooperative member households, 1983	21	15	65	32	38	248	419
Nonmember households, 1983	174	165	380	63	103	1,002	1,887
1983 sample							
Cooperative members	13	10	36	24	18	94	195
Sample population as percent of total ^a	(62)	(67)	(55)	(75)	(47)	(38)	(47)
Nonmembers	29	27	32	11	18	87	204
Sample population as percent of total ^a	(17)	(16)	(8)	(17)	(17)	(9)	(11)
1985 sample							
Cooperative members	12	15	31	20	17	84	179
Nonmembers (farmers and non-farmers)	28	23	37	14	20	100	222
Nonmembers (farmers)	24	23	34	12	16	70	179
Years of cooperative membership in 1985							
Less than 3	5	15	3	7	1	19	50
3-4	7	...	14	4	9	19	53
5-7	...	...	14	9	7	46	76

Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a The percent figures in parentheses represent the percentage of total population covered in the communities by the sample survey.

The composition of the 1985 sample is affected by changes in household characteristics since the 1983 survey. Some households split when the younger generation started its own households, some cooperative members dropped out of the cooperative, and some nonmembers became members. Also, some households could no longer be interviewed because of long-term absence. Between 1983 and 1985, 9 percent of the member sample left the cooperative and 6 percent of the nonmember sample became members. Taking the stratification of the sample into account, these numbers suggest a net increase of members by 19 percent since 1983. This roughly corresponds to the actual change in the membership statistics of the cooperative between 1983 and 1985.

The sample is spread over early and late adopters. Forty-two percent of the sampled households of the cooperative members have been in the scheme for as long as five to seven years. Newcomers are spread over all six communities, while the early adopters are all in the four founding villages of the cooperative (see Table 1).

The field data collection for the 1983 and 1985 surveys was done by the experienced survey staff of the Institute of Nutrition of Central America and Panama (INCAP).

The household-level information collected includes

1. demographics of the household (employment, schooling);
2. health, anthropometrics of children under 10 years of age, and child-feeding practices;
3. housing conditions;
4. access to services;
5. nonfarm income (by individual, by source);
6. agricultural production (inputs, outputs, labor at field level by crop, size of fields, produce sales, input purchases, animal production, land quality);
7. food expenditures and consumption of own-produced food; and
8. nonfood expenditures.

The various types of information are covered over recall periods specific to the nature of the data. Agricultural production covers the crop years 1982/83 and 1984/85 (May-April), and off-farm income covers the 12 months preceding the surveys (November-October 1982-83 and 1984-85). Food and nonfood expenditures are monthly (October 1983, October 1985), with an annual recall for lump sum nonfood expenditures (especially durable goods) added to the 1985 survey that covers November 1984 to October 1985.

In a subsample of the 1985 survey consisting of 40 households in two communities (El Rejón and Santiago de Sacatepéquez), a detailed assessment of intrahousehold decisionmaking and of sexual division of labor and time allocation of household members was undertaken parallel to the large survey (Nieves 1987).

COMMERCIALIZATION OF GUATEMALA'S AGRICULTURE

Guatemala is the third largest in area of the Central American republics, after Nicaragua and Honduras, but its population of about 8.4 million (1984 figure) exceeds that of the latter two countries combined. About two-thirds of the population lives in rural areas; around 60 percent of them are indigenous people who are descendants of the Maya. The indigenous population is mainly concentrated in the Western Highlands of Guatemala where this study was conducted.

The agricultural sector provides about 50 percent of the country's employment and accounts for 25 percent of the gross domestic product (GDP) in the mid-1980s. Agricultural exports hold a share of about 65 percent in total merchandise exports, thus making agriculture the primary foreign-exchange earner of the economy.

Guatemala's highly dualistic agricultural structure is well documented.⁴ A modern, export-oriented, large-scale farm sector and a traditional, subsistence-oriented, small-scale sector have long coexisted. The two sectors are not independent but rather are closely linked through the rural labor market. Labor from the traditional sector in the Western Highlands (a sector operating on an agricultural-resource base per household that in most cases cannot support the bare survival requirements of the family) seeks employment through interregional migration either to the areas of the large-scale export crop sector—mainly in the lower altitude regions—or, in recent decades, to the urban services sector.

This pattern of export crop production and its interaction with the subsistence farm sector has been in existence for decades. Its effects on the subsistence farm sector are substantial (Schmid 1968, 33-45). Yet the focus of this research is not to study these indirect effects but the recent changes in the subsistence sector itself, namely, those resulting from the shift into export crop production by small farmers in the Western Highlands. The traditional dualistic pattern of subsistence and export crop sectors, however, must be kept in perspective to assess the implications of the change in commercialization in the small-farm sector. Clearly, this subsector—though mainly subsistence-oriented in crop production—was already "commercialized" by selling a high share of its labor rather than its crops.

Exports from a Dualistic Agricultural Sector

Agricultural exports from Guatemala may be grouped into traditional and nontraditional exports. The traditional ones in their order of share in total agricultural exports are coffee, cotton, sugar, bananas, and beef. These crops account for 76 percent of agricultural exports in the mid-1980s (Table 2). Among the important nontraditional agricultural exports that account for the remaining 24 percent are cardamom, vegetables, flowers and plants, fruits, and sesame seed. Since the mid-1970s the share of agricultural exports in total merchandise exports has remained stable, but the composition of

⁴ See Nyrop 1983 and the extensive bibliography in this source; also World Bank 1978.

Table 2—Value of agricultural exports from Guatemala, 1975-84

Export Item	1975	1980	1984
	(US\$ million)		
Traditional agricultural exports			
Coffee	164	464	361
Cotton	74	166	72
Sugar	116	69	71
Bananas	35	45	55
Beef	17	29	13
Subtotal	406	773	572
(Percent of total agricultural exports)	(92)	(79)	(76)
Nontraditional agricultural exports			
Cardamom	10	56	100
Vegetables, flowers and plants, fruits	9	68	43
Other ^a	15	75	39
Subtotal	34	199	182
(Percent of total agricultural exports)	(8)	(20)	(24)
Total agricultural exports	440	972	754
Total exports	651	1,520	1,132
(Agricultural exports as percent of total exports)	(67)	(64)	(67)

Source: Based on data from Bank of Guatemala, "Economic Data, 1985" (Bank of Guatemala, Guatemala City, mimeographed).

^a Includes essential oils, fish, gum, honey, cocoa, cotton seed, sesame seed, cotton lint.

agricultural exports has become more diverse. The share of traditional agricultural exports dropped from 92 percent in 1975 to 76 percent in 1984, although traditional exports grew in absolute dollar terms. Increased diversification of the agricultural export sector is a stated policy objective to reduce instability in foreign-exchange earnings due to price fluctuations—for example, of coffee—in international markets (Banco Interamericano de Desarrollo 1986, 74).

Landownership in Guatemala is extremely skewed. The Gini coefficient, which ranges from zero in a situation of perfect equality to 100 in a situation of maximum inequality, was 85.1 for land distribution in Guatemala in 1979—higher than for all other Latin American countries (Hough et al. 1982, 1). The Gini coefficient increased from 82.4 to 85.1 between 1964 and 1979, indicating further inequality (Hough et al. 1982, 2). Two percent of farmers held 67 percent of the agricultural land—land that is generally of better quality than the land cultivated by small farmers.

For those at the bottom of the land distribution, population growth leads to rapid reduction of average farm size. From 1964 to 1979, the average farm size of those under 1.4 hectares (2 *manzanas*) decreased from 1.0 to 0.7 hectare. Sixty percent of Guatemalan farms fall in this group that cultivates 4 percent of the land (Table 3). Most of the subsistence farm households in the Western Highlands also fall in this group; thus, not surprisingly, more than 90 percent of the sample survey households are part of this farm-size class.

Total agricultural land in use increased by 0.8 percent per year between 1950 and 1979. Expansion into new lands did not provide any significant relief for the land constraint burdening the small-farm sector, nor does it provide a potential solution for this problem (Hough et al. 1982). The obvious solution—agrarian reform with redistribution of land from large-scale farms to small farmers—was attempted by governments in the late 1940s and early 1950s, but the attempts were finally blocked when the government was toppled in a coup in 1954 (Kinzer and Schlesinger 1983).

Table 3—Farm-size distribution in Guatemala, 1950, 1964, and 1979

Farm Size (hectares)	Share of Farms			Share of Area		
	1950	1964	1979	1950	1964	1979
	(percent)					
Less than 1.4	47 ^a	44	60	3 ^a	3	4
1.4–3.5	29	31	21	6	7	6
3.5–44.5	22	23	17	19	23	23
44.5 or more	2	2	2	72	67	67
Total	100	100	100	100	100	100

Source: Based on data from SEGEPLAN, *Agricultura, Población, y Empleo en Guatemala* (Guatemala City: SEGEPLAN, 1984).

^a In the 1950 census, farms with less than 0.04 hectare were excluded.

Guatemala's agriculture has continuously and substantially shifted away from staple food production (which includes a large share of subsistence production) to cash crops and production for exports. Basic food crops covered 58.0 percent of agricultural area in 1950 compared with only 37.4 percent in 1979 (Table 4). Cash crops and export crops increased their share in land use from 20.0 to 29.8 percent during the same period. Although this change in cropping patterns mainly took place in the medium-sized farms (3.5–44.5 hectares), the smallest farms are following the same pattern of change. They decreased their basic food crop area from 96.7 to 87.4 percent in this period and increased their area devoted to cash crops.

Since 1979 the area allocated to the major staple foods (maize and beans) has increased somewhat, but yields show a downward trend that has made total staple food production stagnant and reduced the per capita staple food production by a rate of –0.3 percent per year between 1968 and 1982 (FIDA 1985, 57–58).

Table 4—Specialization in crop production, by farm size, 1950, 1964, and 1979

Farm Size (hectares)	Type of Crops ^a	Land Use in Share of Farm-Size Class		
		1950	1964	1979
		(percent)		
Less than 1.4	Basic food crops	96.7	91.1	87.4
	Cash and export crops	3.3	8.5	12.2
	Pasture	...	0.4	0.4
1.4–3.5	Basic food crops	93.5	90.1	84.6
	Cash and export crops	6.2	8.4	14.0
	Pasture	0.3	1.5	1.4
3.5–44.5	Basic food crops	84.8	68.0	64.4
	Cash and export crops	10.8	12.6	19.1
	Pasture	4.4	19.4	16.5
44.5 or more	Basic food crops	18.8	14.4	13.7
	Cash and export crops	35.1	32.1	38.4
	Pasture	46.1	53.5	47.9
Total	Basic food crops	58.0	41.3	37.4
	Cash and export crops	20.0	23.1	29.8
	Pasture	22.0	35.6	32.8

Source: Based on data from SEGEPLAN, *Agricultura, Población, y Empleo en Guatemala* (Guatemala City: SEGEPLAN, 1984).

^a Basic food crops include maize, beans, rice, wheat, potatoes, and traditional vegetables. Cash and export crops include sorghum, cotton, coffee, sugarcane, cardamom, sesame, groundnut, tobacco, rubber, and fruits. Pasture includes permanent pasture and land for fodder crops.

How did overall food availability develop over time against this background of change in production patterns toward exports and the slow growth in domestic food production? Overall per capita staple food availability was stable in the 1960s but declined in the 1970s—from an average of 134 kilograms per capita per year (in wheat equivalent) in 1961-63 to 128 kilograms in 1981-83. In the same period, calories per capita per day increased from 1,937 to 2,080 (FAO, various years). Obviously, relatively more calories come now from nonstaple foods. It should be stressed that such country averages do not really address the food situation properly, especially in countries with such large spreads in income distribution as Guatemala.

Generally, developing countries tend to manage joint growth in the basic food crop and cash crop subsectors or fail to achieve growth in either (von Braun and Kennedy 1986, 27-36). Guatemala, however, appears as an exception to this tendency. Its cash crop sector was growing over the long term while its basic food crop sector stagnated (von Braun and Kennedy 1986, 35). This may be explained by the highly dualistic structure of Guatemala's agricultural sector. This structure does not accommodate positive spillover effects from promotion of traditional export crops through credit, inputs, market infrastructure, and so forth, to the basic food crops, as the two are mainly grown on two very distinct types of farms—large scale versus small scale—as well as in different locations.

The effects of increased commercialization through the introduction of new cash crops for food crop production in the small-farm sector may, however, turn out to be very different from the development path of the isolated expansion of agroindustrial crops in the large-scale farm sector. In principle, positive linkages between new cash crops and the promotion of traditional food crops could be established in this case.

Recent Variations in Agricultural Policy

In the early 1980s Guatemala's substantial export-led economic growth, with low levels of general inflation and an impressively strong currency, experienced a crisis. Between 1982 and 1985, per capita gross national product (GNP) was down by 20.5 percent in real terms (Banco Interamericano de Desarrollo 1986, 5). The Guatemalan quetzal, which was valued at a fixed 1-to-1 rate against the U.S. dollar for more than 40 years, was devalued in 1984 and further devalued in 1985 to about Q3.00-US\$1.00 in the parallel market. A product-specific system that allowed differential access to the parallel-market exchange rate and imposed different shares of the export revenue to be converted at the old 1-to-1 rate has led to numerous variable exchange rates—and implicitly to a host of different export tax levels through exchange-rate regulation. For instance, in early 1986, 25 percent of coffee dollars were to be exchanged at the parallel rate and 75 percent at the official rate. Export vegetable dollars got better treatment by an imposed share of 50 percent at the official rate.

This exchange-rate policy induced equivalent distortions on the import side. A policy of using the foreign exchange acquired through the implicit taxation of exports for importation of so-called essential agricultural imports (such as fertilizer and food) at the old exchange rate was largely ineffective. Fertilizer prices roughly doubled from 1985 to 1986. Thus the input-intensive export crops came under pressure from both sides—export taxation through partly maintained overvalued exchange rates, and the full effect of the devaluation of domestic currency on the input price side. During 1980-84, export values declined faster among traditional export crops (-7.3 percent)

than nontraditional crops (-2.2 percent). On the basis of this experience, the government policy for agriculture, as laid out in the 1984-86 National Development Plan, emphasizes both diversification of export-oriented agricultural production and increased production of food commodities.

The causes of the recent economic crisis must be seen in the context of both the country's violent internal conflicts and the external economic factors, especially the deterioration of terms of trade and substantially higher interest rates for capital investments. In a country with a very small public sector and extremely limited public services for the poor, the economic crisis is assumed to have hit particularly hard the low-income stratum of the population, which in Guatemala is a large proportion of the population.

Poverty in Guatemala is predominantly a rural problem and is particularly concentrated in the Western Highlands. A survey in 1980 classified 36.2 percent of the rural population as absolute poor, as their income was too low to purchase an adequate diet. These rural poor constituted 73.5 percent of all poor. Agricultural income per household in the Western Highlands was about 40 percent below the average of other rural areas in the country (Guatemala 1982).

Evolution of Commercial Agriculture in the Large- and Small-Farm Sectors

The dualistic structure of Guatemala's agriculture, with large-scale farms versus *minifundus* (mainly in the hands of indigenous farmers), is largely an inheritance of the structural change introduced by the Spanish during the colonization of the country (Nyrop 1983). With the introduction of coffee cultivation after the 1840s, much of the best land in the highland departments was absorbed into expanding coffee haciendas. The indigenous population who had been farming these lands for generations were forced to move to higher, less fertile lands in order to continue growing their subsistence crops—maize and beans (Hough et al. 1982, 21-24). This change took place mainly between 1870 and 1920.

Another major export-oriented change with long-term consequences, not only for agriculture but also for the political stability of the country, emerged in the 1920s and 1930s when the United Fruit Company acquired large landholdings—mainly for banana plantations in the fertile lowlands. Concessions to the company by the government totaled about 190,000 hectares (Kinzer and Schlesinger 1983).

The basic effect of the traditional export orientation in Guatemala's agriculture was an increased concentration of land in large farms and of the indigenous population in the remaining high-altitude areas with unfavorable land quality. At times, forced labor obligations were imposed on this population to fill the labor demand in the export crop sector (Nyrop 1983). Through reduction of the land-resource base for the indigenous population, the opportunity cost of labor on their own small holdings was reduced, thus assuring a cheap labor supply to the large-scale farmers.

Technological change in the food crop sector was not exceedingly successful in Guatemala (CGIAR 1984). Growth in yields of maize was 1.6 percent per year between 1971-73 and 1981-83. Only a small surplus of the traditional food crops in the small-farm sector is produced for marketing, so these crops have not become a source of cash income. In the typical Western Highlands situation, about 90 percent of the maize grown is retained for own consumption. It is only recently that maize production has increased on large-scale farms.

Export vegetables, the focus of this study, were introduced to Guatemala in the mid-1970s with substantial foreign investment.⁵ Originally, the scheme operated with an integrated production-processing (screening, packing, cooling) exportation system in the hands of one company. Soon the economic advantage of contract growing in the smallholdings in the Western Highlands became apparent. Company crop production was phased out and farmers in selected villages were awarded contracts. The main commodities were cauliflower, broccoli, snow peas, and brussels sprouts.

This system continues to operate and the farmers of the Cuatro Pinos cooperative, the focus of this research, were part of this contract system in the early 1980s. Kusterer, Estrada, and Cuxil (1981, 6-9) point out the rather different effects of the contract-growing scheme in different locations of its operation. The access to inputs and to restricted delivery for the contracted amounts of outputs was, at various locations, a problem to farmers. In general, farmers were very eager to join the scheme. In fact, a major short-term problem was that farmers had moved unexpectedly fast into production of some of the vegetables and the marketing and export channel did not keep up with this rapid adoption, thus leading to critical frictions between the contract partners in the cooperative (Kusterer, Estrada, and Cuxil 1981, 17-24).

Export vegetable production is done at the individual farm level in the context of contract growing or independently relying on market middlemen, called *coyotes*. A substantial part of the export vegetable production stems from farmers who have formed cooperatives. The positive attitude of Guatemalan peasants toward cooperation in production with households from the same ethnic group is a good basis for agricultural cooperatives (Bossen 1984). In 1984, 812 cooperatives with more than 143,000 members were registered, of which 382 cooperatives were agricultural ones.⁶ More than half of all cooperatives are located in the Western Highlands, the area of this study. Agricultural cooperatives had on average 167 members in 1983—less than half as many as the Cuatro Pinos cooperative had at that time.

⁵ A very comprehensive description and evaluation of the early operation is given in Kusterer, Estrada, and Cuxil 1981.

⁶ Of the 812 cooperatives, 731 were considered actually active at the end of 1983 according to El Instituto Nacional de Cooperativas (INACOP), as stated in FIDA 1985, 137.

INITIATORS AND OPERATORS OF EXPORT CROPPING IN SMALLHOLDER AGRICULTURE: THE CUATRO PINOS COOPERATIVE

Food and agricultural policy plays a key role in shaping the commercialization of traditional agriculture. Commercialization of subsistence agriculture does not simply develop as a result of changes in economic incentives or new technology at the farm level, the processing level, or in marketing. To a large extent, the commercialization process is also influenced and designed by actors at the local level and, especially in case of export crops, by actors who are quite removed from the local farm-production scene. The Cuatro Pinos cooperative is an interesting case in point.

Socioeconomic Environment of Cuatro Pinos at the Outset

Cuatro Pinos is active in six villages in and around the *municipio* (county) Santiago Sacatepéquez, which is located about 35 kilometers west of Guatemala City.⁷ Storage and processing facilities for the export vegetables are in Santiago, which is the base of the cooperative. The community is connected to the paved road of the Pan-American Highway, which is 5 kilometers away. The altitude is around 1,900-2,000 meters.

According to a survey carried out in 1977, 10 percent of the cultivated area of the *municipio* was devoted to the production of different vegetables. The remaining 90 percent was for maize and beans (Hintermeister 1986, 10). Between 10 and 15 percent of family heads living in Santiago were working in Guatemala City. In general, they were relatively young and had access to small parcels of land below subsistence levels.

In one of the main villages in which Cuatro Pinos is operating, Santa María Cauqué, a comprehensive longitudinal study on population, agriculture, nutrition, and health depicts the situation before implementation of the cooperative (Mata 1978). Between 1963 and 1971, the population increased at a rate of 3.1 percent per year, while farm size decreased at a rate of 3.5 percent. Since then, population growth has increased at a rate of 3.5 percent per year. This particular village, however, is a rather untypical case. The trend toward cash crops was established even before the establishment of the cooperative, but the cooperative reinforced the trend. This village was more commercialized at the outset than the other five villages of the cooperative, mainly because of its favorable access to transport and communication infrastructure by virtue of its proximity to the Pan-American Highway. In the 1960s the cropping pattern changed gradually, showing a reduced share of subsistence crops. From the early 1970s to 1985, the share dropped from 70 to 50 percent, corresponding to the increased share of new export crops and traditional vegetables (Table 5).

The incidence of severe protein calorie malnutrition (PCM) was found to be considerable in Santa María Cauqué. In a cohort analysis between 1964 and 1969, 13 percent

⁷ Since 1987, the cooperative has operated in eight villages.

Table 5—Average farm size, population, and land use pattern in Santa María Cauqué, 1963-85

Item	1963	1967	1971	1985
Farm size (hectares)	1.2	1.1	0.9	0.8
Population	1,071	1,254	1,370	2,225 ^a
Land use (percent)				
Maize and beans	78.7	73.2	70.5	49.5
Vegetables and other crops (including export crops)	21.3	26.8	29.5	50.5

Sources: Based on data from L. J. Mata, *The Children of Santa María Cauqué: A Prospective Field Study of Health and Growth* (Cambridge: Massachusetts Institute of Technology Press, 1978), p. 18; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Estimated on the basis of a 1983 census done by the Institute of Nutrition of Central America and Panama.

of 1-year-old children, 27 percent of 2-year-old children, and 9 percent of 3-year-old children were found to be affected by PCM (Mata 1978, 298). Most cases of severe PCM occurred in the rainy season (June-September), when infectious diseases—particularly measles, diarrhea, and respiratory infections—are most frequent. In explaining this pattern of the prevalence of PCM, Mata (1978, 302) concludes that “the relationship of food availability, marketing, and cash to malnutrition deserves serious investigation.”

At the outset, the general socioeconomic environment and health and nutrition situation in the area of the Cuatro Pinos communities appeared to be not particularly different from the general situation in the Western Highlands. Some special features of the economic environment are, however, noteworthy. Closeness to the capital city and the good infrastructure facilitated market integration with fresh vegetables. Average farm size is below the average in the Western Highlands. Also, there are no big farms in the area. This has two implications: there were no serious conflicts over land—at least in the 1970s—and the influence of nonindigenous farmers on the social organization and economic activities in the *municipio* was small. Thus there was neither an important social force to oppose the local development of the cooperative nor landowners who considered the promotion of the profitable labor-intensive crops as a threat to their control over the labor market (Hintermeister 1986, 11-12).

The Evolution of Export Cropping by Cuatro Pinos Farmers

The adoption of export vegetable production by small farmers in the Western Highlands is determined by long-term changes in economic variables, especially the increased demand for these crops in U.S. and European markets and the growing labor-land ratio on small farms. Both these factors increase the comparative advantage of labor-intensive crops in rural environments where there is increasing (seasonal) underemployment. International development assistance organizations played a catalytic role in the beginning for the rapid use of potential economic benefits from nontraditional export crop production in the Western Highlands. The interaction of four groups of actors finally led to the rapid expansion of export vegetable production.

1. External development assistance organizations were instrumental at two different levels. First, they provided the seed money (loans) to a private company, Alimentos Congelados S.A. (ALCOSA), to open up the export channel (Latin American Agribusiness Corporation S.A. [LAAD] and the U.S. Agency for International Development [AID])

played a role in this). Second, they stimulated the formation of the cooperative, implemented its programs, and assisted in securing access to the export channel through private exporters (Swiss Group, a Swiss nongovernmental organization).

2. An external private company (ALCOSA, a subsidiary of U.S.-based Hanover Brands, Inc.) provided the know-how and the export channel to the U.S. market, including such related infrastructure facilities as cold storage.

3. Guatemalan public institutions provided the know-how on agricultural technology (Instituto de Ciencias y Tecnologías Agrícolas [ICTA]) and farm-level credit (Banco Nacional de Desarrollo Agrícola [BANDESA]). INCAP developed vegetable-processing equipment.

4. Local farmers formed the Cuatro Pinos cooperative, which organizes export vegetable production and provides field-level extension, input supply, produce collection, selection, and storage. Lately the cooperative has organized its own exports independently from the ALCOSA outlet, both to the United States and to Europe.

The interaction of these players in the process of increased commercialization was quite different in the various phases of the process. The following calendar of events that led to the expansion of vegetable production for exports at Cuatro Pinos sheds light on this:

Year	Export Vegetables in Guatemala	Cuatro Pinos Cooperative
1970	LAAD founded (LAAD's Central American subsidiary mainly funded through USAID loans)	
1971	ALCOSA began operations in Guatemala with a LAAD loan (freezing fruits and vegetables)	
1975	ALCOSA purchased by Hanover Brands, Inc., and expanded with new loans from LAAD to export vegetables to United States (okra, broccoli, cauliflower, brussels sprouts)	
1976	Main production of vegetables for export by ALCOSA started on company lands leased by ALCOSA; small experiments with small farmers began	Earthquake in the Western Highlands; death toll about 30,000; Swiss Group comes to rebuild Santiago Sacatepéquez
1977	Buying stations set up to buy cauliflower from small farmers in highlands	Swiss Group's development programs—food aid, literacy courses, along with reconstruction work in villages; formation of groups that later formed the cooperative

1978	Rapid expansion of cauliflower program	Implementation of agricultural programs—maize improvement, traditional vegetables; contract with ALCOSA through Swiss Group for broccoli and cauliflower production in Santiago Sacatepéquez
1980	Production on ALCOSA's own farmland closed; all cold-weather vegetables now from small highland farmers (about 2,000 farmers in purchasing program, delivering to 17 stations); crisis of ALCOSA—contracts were signed for much more broccoli and cauliflower than plant's processing capacity; breakdown of field organization; suspension of purchases; losses to farmers	Construction of buildings for cold storage and packing at cooperative headquarters at Santiago Sacatepéquez; contractual arrangements with fresh snow pea exporters
1981	Expansion of processing capacities of ALCOSA; change in contractual arrangements with farmers	Rapid expansion of cauliflower, broccoli, and snow pea production and direct exports by cooperative to United States
1987	Five companies (Guatemalan) in addition to ALCOSA started frozen-vegetable business	Further expansion of cooperative; construction of own freezing, processing facilities; 20 percent of exports to Europe

Production technology, management, and on-field supervision requirements for export vegetables are well suited to small farms. The early experience of ALCOSA with crop production and procurement clearly indicates that the production of export vegetables (broccoli, cauliflower, snow peas) has rapidly decreasing returns to scale. The production initially started on land leased by ALCOSA where up to 400 people were directly employed by the company. Then ALCOSA contracted middle-sized farms of 20-40 hectares operated by agricultural entrepreneurs and, finally, shifted to small farmers. Although ALCOSA initially intended to depend on its own farming for raw material, it soon began to rely more on its outgrowers (Kusterer, Estrada, and Cuxil 1981, 13). The experience showed that nontraditional commercial farming entrepreneurs on the middle-sized farms were not a satisfactory source of supply.

The small farms' comparative advantage in vegetable production is due not only to the high labor intensity of the work tasks but also to careful on-field management and supervision requirements to meet quality standards that are better fulfilled by the small farmers experienced in traditional vegetable production. These production characteristics are important features for the sustainability of export vegetable production in the hands of small farmers. Along its development path, Cuatro Pinos has benefited from institutional support and soft loans for its investments but not from subsidies for on-farm production. The institutional support and know-how transfer was probably the most important ingredient for the growth of the cooperative.

By 1987, Cuatro Pinos had expanded to 1,150 members, compared with 177 members in 1979. The cooperative farmers were growing nearly 300 hectares of export vegetables in 1985. More than half of this area was devoted to snow peas. The area under these crops has quadrupled since 1980/81 (Table 6). At the cooperative headquarters, about 150 persons—more than half of them women—found employment in screening and packing work.

Sustainability of Export Crop Production by Small Farmers

Export vegetable production is frequently considered risky for small farmers. Various types of risks are distinguished: risk of crop failures (pests, weather), risk of price collapses, and risk of a breakdown of the marketing institutions (the domestic or external part of the channel or both).

The production risk at the farm level will be discussed later on the basis of farm survey data. The two "institutional" risks are addressed in the following sections.

Price Risk and Exchange-Rate Policy

Prices of export vegetables, and those of snow peas in particular, are extremely unstable compared with, say, staple food prices. Highest and lowest prices paid to Cuatro Pinos farmers in 1985 for snow peas of similar quality ranged from Q0.10 to Q2.00 with a median of about Q0.80 per pound (see Figure 2). These fluctuations reflect directly the actual price movements in the export markets (especially the spot markets in Miami, Los Angeles, and London). The fluctuations are the result of short-term supply-and-demand changes. Various regions enter the markets of these products at different times (for example, Mexico, California, and the Dominican Republic). Other types of fresh vegetables probably induce substitution effects on the demand side in various seasons, but little is known about these. However, it is important to note that the high degree of price instability of snow peas from week to week does not translate into a similar instability of returns from the crop. Harvesting of the crop starts 9 weeks after planting and extends over 10 to 12 weeks with three pickings of the crop per week. The grower is thus facing an average price over the whole harvesting period of a field. A farmer who, for example, planted his crop in the beginning of June 1985 and was harvesting in August, September, and October delivered his crop at prices ranging from Q0.10 to Q1.50 per pound with an average—depending on volume at the specific points in time—of about Q0.55 per pound. The price fluctuations listed

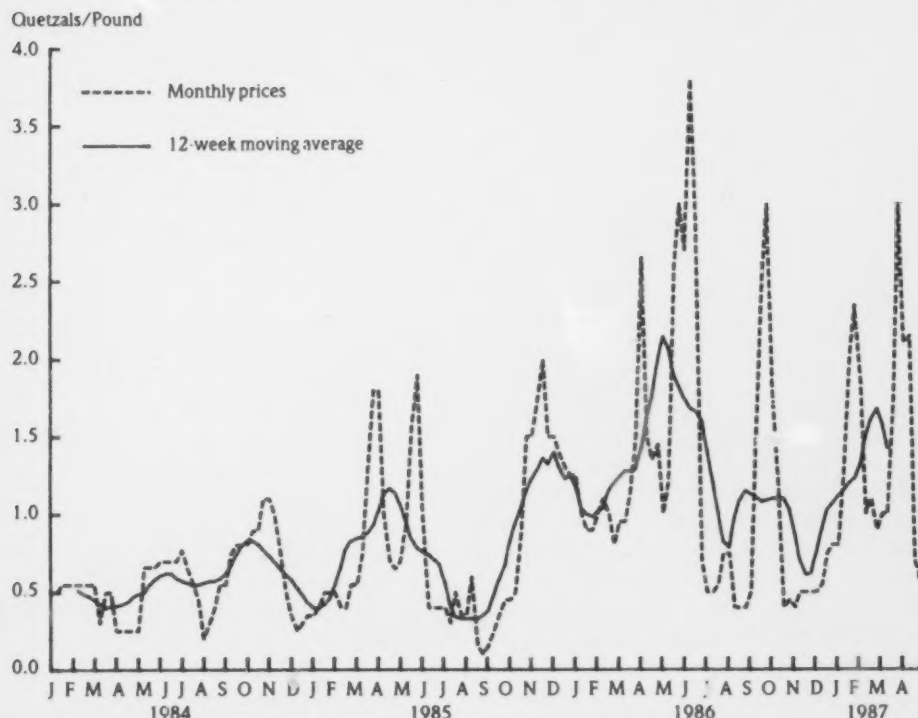
Table 6—Area under export vegetable crops marketed by the Cuatro Pinos cooperative, 1980-85

Crop	1980/81 ^a	1984/85 (hectares)	1985/86
Snow peas	6	90	170
Cauliflower	61	67	67
Broccoli	0	10	45
Parsley	0	2	7
Total	67	169	289

Source: Records of Cuatro Pinos cooperative.

^a Rough estimate.

Figure 2—Snow pea prices paid to farmers by cooperative, 1984-87



Source: Records of Cuatro Pinos cooperative.

in Figure 2 are thus smoothed out in 12-week moving averages with which they actually translate into gross revenues from the crop. Farmers also can—and actually do—grow the crops in phases on different plots at different points in a year, thus further reducing the price risk.

Such price variability is not necessarily a problem for farmers if it represents a seasonal pattern with predictable ups and downs in prices. For some time it was assumed that snow pea export prices were at a seasonal high during September-December and farmers were accordingly advised to plant for harvest at that time. In recent years, however, no clear seasonal price pattern has occurred, so farmers have been confronted with a high degree of uncertainty. Developments on the supply-and-demand side of the international market for snow peas—for example, increased demand from Western Europe and increased supply in various seasons from other producing regions such as the Dominican Republic, other Central American countries, and California—appear as important factors. Also, little is known about substitution effects of changes in prices of competing types of vegetables on the formation of prices for such luxury vegetables as snow peas. Predicting future crop prices, which is crucial for the sustainability of the export operation, is hardly possible with any acceptable margin of error. Demand in the rich countries of the North appears to be rising. However, as long as new technologies are not developed that would permit the cultivation of the crop with substantially lower labor input in comparable climatic zones, small farmers in the

Guatemalan highlands have a sustained comparative advantage due to the local labor supply situation. Deflated average prices for snow peas paid to cooperative farmers have shown neither a decreasing nor an increasing tendency since 1984: first-quarter averages (January-April in 1984 prices) were Q0.50 per pound in 1984, Q0.36 in 1985, Q0.76 in 1986, and Q0.61 in 1987. The variability of prices also shows no particular tendency in these years.

Comparative advantage of export vegetables at the farm level is directly affected by the exchange-rate policy, which determines changes in the price ratio between traded and nontraded agricultural products and inputs. Recently, exchange-rate policy changes in Guatemala have introduced an additional uncertainty element into the price environment. These policy changes are not predictable for farmers; thus the erratic exchange-rate policy discussed in Chapter 3 establishes one component of the price risk facing the farmer.

The overvalued exchange rate in the early 1980s and the multiple exchange-rate system in place in 1985/86 translate into a changing taxation of the export vegetables. In mid-1985, the exchange-rate system for vegetable exports required 50 percent of the sales value to be exchanged at the official rate (Q1.00 = US\$1.00) and permitted the other 50 percent to be exchanged at the parallel rate (about Q1.00 = US\$0.27). Even taking into account a common practice of underreporting the sales value, this exchange-rate policy resulted in an export tax of about 25 percent for snow peas (see Table 7). This tax favors production of domestically consumed traditional vegetables and, to some extent, the subsistence crops (maize and beans). It also suggests that returns to farm labor in the small enterprises in the Western Highlands are cut. The export tax for the labor-intensive new vegetables in the Western Highlands had adverse effects on employment and real income of the rural poor.

Table 7—Effect of exchange-rate policy on export vegetable producer price: an example from a snow pea sale by Guatemala to the United States, July 1985

Affected Item	Price and Tax Effects
(1) Actual "return price" of a shipment	US\$0.35/pound
(2) Declared "return price" of shipment (lowest price noted on market in reference period of shipping)	US\$0.25/pound
(3) 50 percent of declared "return price" at official exchange rate (Q1.00 = US\$1.00)	Q0.125/pound
(4) 50 percent of declared "return price" at parallel exchange rate (Q1.00 = US\$0.27)	Q0.463/pound
(5) Difference between actual and declared "return price" at parallel exchange rate (Q1.00 = US\$0.27)	Q0.407/pound
(6) Actual "return price" in domestic currency (position [3] + [4] + [5])	Q0.995/pound
(7) Tax due to official exchange rate applied to 50 percent of declared "return price" (in position [3])	Q0.338/pound
Tax in percentage of actual "return price" position (1) at parallel exchange rate	25.4 percent

Source: Information from traders in Guatemala.

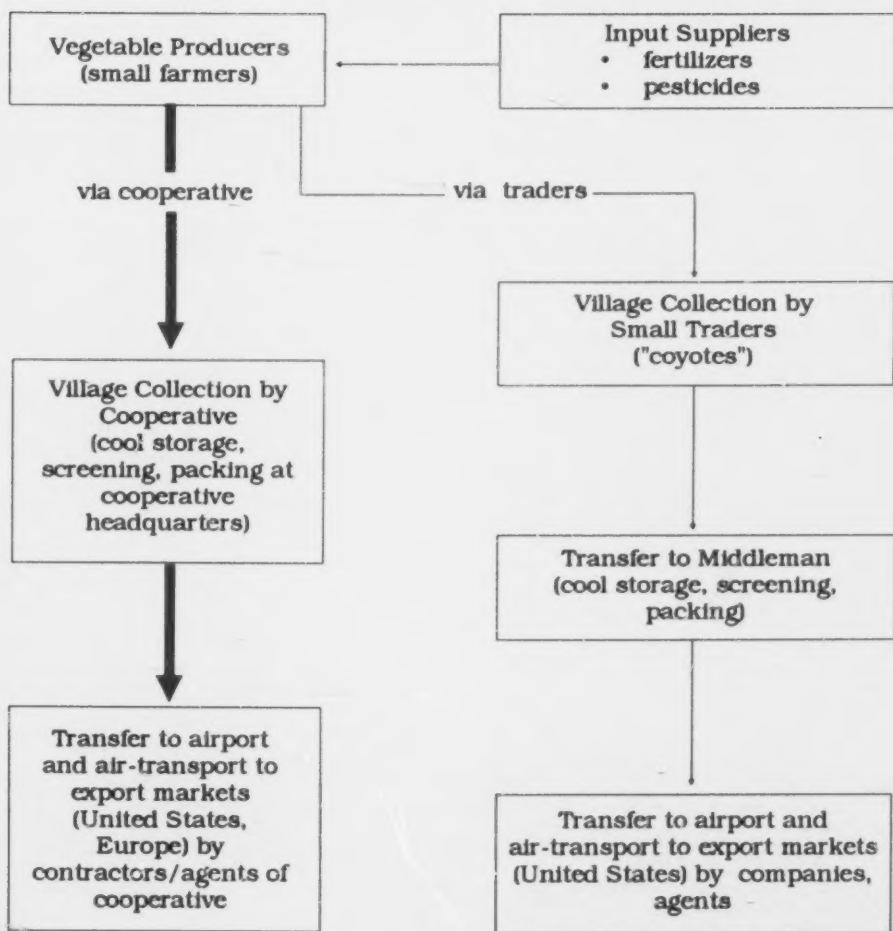
Note: "Return price" is the net price c.i.f. U.S. market (Miami) after transport and handling costs are deducted. It is "returned" to the exporting cooperative, which passes it on to farmers after deducting local marketing margins.

Risks in the Marketing Institutions

It is obvious that the sustainability of the export operation of a perishable commodity largely depends upon the proper functioning of the marketing channel of inputs and outputs (Figure 3). Input markets of fertilizers and pesticides appear to be well integrated in Guatemala. Domestic prices of inputs are largely determined by international price changes and by the exchange-rate policy.

The output marketing in the study area is largely via the Cuatro Pinos cooperative. The sustainability of this institution is crucial for the profitability of export crop production. Cooperatives in the Western Highlands have a mixed record of success. It has not been uncommon for cooperatives to collapse because of dishonest management practices or political reasons, especially during the period of violent conflicts in the

Figure 3—Marketing channels for fresh export vegetables from Guatemala



late 1970s and early 1980s. The survival and growth of Cuatro Pinos appears as a successful exception to the rule.

The technology required for the operation of the first phase of the export channel within the country is simple and does not require major external inputs or expertise. An important component of the marketing system is the flow of information from the export market to the cooperative and the growers. Increasingly developing its outreach, the cooperative has recently started shipping to European markets. This international flexibility further reduces the risk of dependence that occurred in the early stage of the export vegetable production when ALCOSA was the single buyer. In 1987 five companies besides ALCOSA processed frozen vegetables, and six other companies are operating the fresh vegetable export channel that now provides for a highly competitive market structure. Recently the cooperative has started to process dried vegetables (parsley) in storable form and has begun construction of its own freezing facility.

Also, farmers now have an alternative market outlet for export vegetables, in addition to the cooperative, via small traders who collect at the village level. The quantities acquired by these traders appear to be small in the study region. This competitive outlet reduces the risk to farmers that their access to export markets would break down in case of a collapse of the cooperative.

The marketing costs of fresh vegetables (for example, snow peas) are high. The consumer price in the United States was about five times the producer price paid in Guatemala in 1985 (Table 8). Apart from a 10 percent sales commission to the brokers

Table 8—Marketing costs of a fresh export vegetable (snow peas) from Guatemala to the United States, 1985

Item	Price per Pound	Prices and Marketing Costs in Percent of U.S. Consumer Price
Price paid to farmer	Q0.90 ^a (US\$0.57) ^b	19.0
Cost of marketing		
Local cost at cooperative		
Loss due to final selection	Q0.05	
Packing box	Q0.15	
Labor	Q0.03	
Coding	Q0.02	
Overhead or management	Q0.03	
Subtotal	Q0.28 (US\$0.08) ^c	2.7
Cost of exporting to the United States		
(Air) freight to Miami	US\$0.30	
Freight to sales place	US\$0.03	
Cooling	US\$0.02	
Customs	US\$0.03	
Commission for broker (10 percent of gross sale)	US\$0.10 (approximate)	
Subtotal	US\$0.48	16.0
Total marketing cost	US\$0.56	18.7
Total cost of produce c.i.f. Miami	US\$1.13	37.7
Marketing margin and profit in the United States	US\$1.87	62.3
Price to U.S. consumer	US\$3.00 ^d	100.0

Source: Records of Cuatro Pinos cooperative.

^a Approximate weighted average price for farmers in 1985; actually fluctuated between Q0.15 and Q2.00 per pound.

^b The weighted split exchange rate 50 percent at parallel (= Q3.65) and 50 percent official (= Q1.00) is used here.

^c The parallel exchange rate is applied here.

^d In 1985, this price varied between US\$2.00 and US\$4.00 per pound.

who arrange the sale in the U.S. market, the marketing costs (c.i.f. Miami) are not affected by the sales value. The marketing costs to Miami were about 18.7 percent of the consumer price, or roughly equal to the producer price. Any fluctuations in the U.S. market price are fully and immediately transmitted to the (Guatemalan) producer. Cutting marketing costs appears to be a desirable approach to benefiting producers and consumers, but in this particular case not much space appears available for cost-cutting measures.

Some interesting conclusions can be drawn from the assessment of "institutional risks" faced by the export crop producer. These risks can be reduced by opening up alternative marketing and processing lines at a level close to the farmers as well as by diversifying the export markets to avoid monopsonistic pressures. Options for diversification in production and processing and in export target markets within the group of export vegetables are substantial and have effectively been exploited as risk-reducing measures. The know-how for this—transferred via an institution such as a cooperative—may be at least as advantageous to farmers' income stability as any attempts to efficiently organize on-field production stability.

It is in the best interest of farmers that cooperatives and merchants not only coexist and compete at the produce-collection level but also operate independent export lines. This has finally been achieved in the area where Cuatro Pinos operates. However, such competitive structures cannot be expected to arise in the earliest phase of new export crop introduction. Monopsonistic patterns and related problems appear more likely, as in the early phase of export vegetable production (see Chapter 2). The export vegetable production of Cuatro Pinos started out as a contract activity with monopsonistic characteristics—a branch of a multinational corporation being the sole buyer in the country. Over a period of five years, the cooperative changed substantially as it began to operate independently and competitively in the regional and international markets, and as other private companies were set up. This development is basic to the reduction of the institutional risk involved in export crop production.

EFFECTS OF THE NEW EXPORT CROPS ON AGRICULTURAL PRODUCTION, INCOME, AND EMPLOYMENT

Adoption of Export Crops by Subsistence Farmers

Agriculture in the survey area was formerly dominated by production of maize and beans, with 10 percent of the land devoted to vegetables for the local market. Those farm households who are not members of the export crop cooperative and who live in the more remote sample villages still show this cropping pattern in 1985. In villages such as El Rejón, Pacul, and Pachalí, maize and beans cover 84-96 percent of the crop area of nonmember farms (Table 9).

The important relationship of access to infrastructure and degree of market integration is revealed by the case of Santa María Cauqué, which is located at the highway to Guatemala City. There, even nonmember households plant only 51 percent of their land with subsistence crops.

Cooperative members farm on average 0.94 hectare, while nonmembers farm 0.66 hectare. Comparisons of the two groups, therefore, must take the farm-size difference into account. Accordingly, most agriculture-related information is presented by farm-size classes in this chapter. It is interesting to note that with these holdings and the allocation of 52 percent of land to subsistence crops by members and 78 percent by nonmembers, households in both groups allocate on average about the same land area to subsistence crops (members, 0.49 hectare, versus nonmembers, 0.51 hectare).

Table 9—Farm size and cropping patterns of members and nonmembers of the Cuatro Pinos cooperative, 1985

Farm Size/Crops	San Matéo	El Rejón	Santa María Cauqué	Pacul	Pachalí	Santiago	Total Average
	(hectares)						
Average farm size							
Members	0.82	1.15	0.86	0.61	1.06	0.85	0.94
Nonmembers	0.64	0.95	0.83	0.80	0.58	0.54	0.66
	(percent of area)						
Maize, beans							
Members	48.8	62.6	41.3	45.3	42.4	57.7	51.8
Nonmembers	81.6	83.9	51.0	87.2	95.5	81.9	77.8
New cash crops							
Members	45.9	35.4	38.8	41.8	53.3	35.9	39.3
Nonmembers	4.0	8.0	22.1	3.3	1.5	7.3	8.9
Traditional cash crops							
Members	5.3	2.1	19.9	12.9	4.4	6.4	9.1
Nonmembers	14.5	8.1	26.9	9.5	3.0	10.9	12.8

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Parts may not add to totals because of rounding.

Export crop production is open to every farmer in the six communities where the Cuatro Pinos cooperative is active. Because merchants outside the cooperative have recently begun operation of another marketing channel for the new export crops, the option to grow export vegetables is not entirely tied to membership. However, with the exception of Santa María Cauqué, a centrally located village where many merchants base their operations, only a very small group of nonmember farmers grows the new crops. This means that becoming an export crop farmer is in most villages synonymous with becoming a cooperative member. This decision is a matter of free choice.⁸

The major decisions made in commercial and subsistence agriculture are decisions that are mostly made either exclusively by the male head of household or jointly by men and women but dominated by men. Nieves (1987) finds that the presence of the cooperative seems not to have altered this relation, at least not in the short term. In her case study on 21 households that are a subsample of the INCAP/IFPRI survey in 1985, Nieves found that the decision to become a member was, in all 21 cases, prompted by the male head of the household. In 16 of these cases, the male head asked the wife's opinion before taking any action. There are no legal or statutory barriers to female participation in the cooperative as members in their own right, yet very few women have membership status (5 out of more than 1,000 members in 1987). Nieves states that women in the study area will assume only public, visible roles that are culturally sanctioned. Applying to the local committee for membership would be an example of a public action traditionally not open to women. Cooperative membership is not a status that women feel they can attain, so they do not apply.

Membership in the cooperative is open to crop growers (but not necessarily to landowners) and small farmers by local standards (no member has more than 3 hectares). Members are obliged to participate in scheduled meetings of the organization and to pay a one-time membership fee of Q38. This enrollment fee is not negligible, as it roughly corresponds to 12 days' wages for a farm worker.

To test the determinants of adoption of export cropping, a probit model is estimated in which the dependent variable equals 1 if the household is an export crop grower, and zero otherwise:

$$Y_i^* = \beta' X_i + u_i, \quad (1)$$

where

$$Y = 1 \text{ if } Y_i > 0, \text{ otherwise}$$

$$Y = 0, \text{ and}$$

$$\text{Probability } (Y_i = 1) = \text{Probability } (u_i > \beta' X_i) = 1 - F(-\beta' X_i),$$

where F is the cumulative distribution function for u .⁹ The β' are maximum likelihood estimates. The bias toward a higher (nonrepresentative) members' share in the sample is taken into account in estimating the probit model. The true proportion of members versus nonmembers, known from the 1983 census information and the cooperative

⁸ For the first time, the cooperative was closed to new members in the fall of 1986, as the rapid expansion of members was considered unmanageable by the cooperative leadership. More members were admitted later, but the cooperative was closed to new members again in 1988.

⁹ For a description and discussion of the probit model, see, for example, Maddala 1983, 22-27.

records, is used to weigh the observations.¹⁰ The theoretical concept of the model application is the following: Income potentially earned off-farm determines the opportunity cost of working on-farm. In the long run, earning off-farm income versus increased on-farm work growing the labor-intensive export vegetables is a choice facing farm households. This choice is determined by the off-farm versus on-farm opportunity costs of family labor. Endowment of human capital and established off-farm employment opportunities determine these relationships for a specific household.

It is hypothesized that the choice to become an export crop grower was determined by the expected income increase, which can be assumed to be determined by the resource endowments of the farm (farm size, land quality) on the one hand, and the access to alternative, relatively secure off-farm employment on the other. It should be noted that only a secure (formal) off-farm income source enters here as an exogenous factor, since high substitution of daily wage earnings and occasional trading income versus on-farm work in the new export crop prevails, as is shown later.

It is further hypothesized that household labor force size and composition (women's share) may be a factor for adoption. A larger household labor force may enhance adoption of the labor-intensive crop, and a higher share of women's labor may induce a different balance of preferences and bargaining positions in the household. Since the decision is mainly that of the male head of household, his age, education level, and attitude toward traditional agriculture are other factors of hypothetical impact for the adoption decision.

The access of villages to infrastructure affects adoption of the new crops. This and the stepwise expansion of the cooperative into some of the villages suggest the inclusion of village-specific variables in the model. Based on these hypotheses, the adoption model is specified as follows:

$$\begin{aligned} \text{EXG} = f(\text{FSZHA}, \text{WLQ}, \text{FOFFY}, \text{LAB}, \text{RWOMLAB}, \\ \text{HHAGE}, \text{HHEDUC}, \text{HHTRAD}, \text{VILLAGE1}, \dots, 5), \end{aligned} \quad (2)$$

where

EXG	= export crop grower (= 1 if more than 10 percent of area in nontraditional export crops, else = 0),
FSZHA	= farm size (hectares),
WLQ	= land quality index (1 = best, . . . , 4 = worst),
FOFFY	= household income from formal off-farm employment (quetzals per year),
LAB	= total labor available in the household (that is, persons of working age), not disabled and not long-term absentees (in man equivalents),
RWOMLAB	= share of female labor in total labor of household,
HHAGE	= age of head of household (years),
HHEDUC	= household head's education (years of schooling),

¹⁰ The approach is described in Manski and McFadden 1982.

HHTRAD = household head's attitude toward maize production being "traditional" (= 1 if stated that most important reason for growing maize was for food and that second most important reason was that he grew maize to this extent because he always did so; else = 0), and

VILLAGE 1-5 = dummy variables for villages 1 . . . 5 = 1 each (else = 0); villages as listed in Table 1 from left to right.

The probit estimates are listed in Table 10 and can be used to derive linear probabilities β_{LP} , which can be approximated (see Amemiya 1981) by

Table 10—Probit estimate of export crop adoption

Independent Variable	Coefficient	t-Value	Approximate Probability of Joining Export Crop Production*	Mean Value of Variable	Standard Deviation
FSZHA	0.65970	5.105	0.2630000	0.689	0.644
WLQ	-0.19191	-1.109	...	2.120	0.456
FOFFY	-0.00021	-2.540	0.0000848	406.600	932.900
LAB	-0.08476	-1.544	...	3.780	2.360
RWOMLAB	-1.00440	-2.016	0.4020000	0.466	0.179
HHAGE	-0.00822	-0.833	...	38.700	12.400
HHEDUC	0.32280	0.692	...	2.930	1.730
HHTRAD	-0.36682	-2.263	-0.1470000	0.545	0.489
VILLAGE 1	-0.54760	-1.953	-0.2190000	0.119	0.324
VILLAGE 2	0.17560	0.692	...	0.113	0.317
VILLAGE 3	0.78250	3.632	0.3130000	0.186	0.389
VILLAGE 4	-0.23840	-0.811	...	0.076	0.265
VILLAGE 5	-0.16220	-0.558	...	0.095	0.287
INTERCEPT	0.72380	1.258	...	...	...

Notes: Dependent variable: Export crop grower (= 1, else = 0). Number of observations: 357. Chi-squared: 108.06.

- FSZHA = farm size (hectares),
 WLQ = land quality index (1 = best, . . . , 4 = worst),
 FOFFY = household income from formal off-farm employment (quetzals per year),
 LAB = total labor available in the household (that is, persons of working age) not disabled and not long-term absentees (in man equivalents),
 RWOMLAB = share of female labor in total labor of households,
 HHAGE = age of head of household (years),
 HHEDUC = household head's education (years of schooling),
 HHTRAD = household head's attitude toward maize production being "traditional" (= 1 if stated that most important reason for growing maize was for food and that second most important reason was that he grew maize to this extent because he always did so; else = 0), and
 VILLAGE 1-5 = dummy variables for villages 1 . . . 5 = 1 each (else = 0); villages as listed in Table 1 from left to right.

* The values in this column are the β_{LP} for the parameters estimated with a reasonable degree of statistical significance (above 95 percent level).

$$\hat{\beta}_{LP} = 0.4 \beta'. \quad (3)$$

The estimation results indicate that the decision of households to adopt the new export crops is not independent of household and farm characteristics:

1. Although all farms in the sample are small by almost any standard, an increase in size of farm significantly increases the probability of becoming an export cropper. Applying the above-mentioned conversion factor of 0.4 to the parameter estimate (FSZHA in Table 10) suggests that one additional hectare of farm size increases the probability of growing export vegetables by 26 percent. The adoption-farm size relationship is complex. This finding of increased probability of adoption *within* the small-farm sector with rising farm size is not contradictory to the earlier finding that the new export crops moved in a trial-and-error path from production on large-scale exporter enterprises to contract growing on medium-sized farms of 20-30 hectares to the small-farm sector. As the probability of adopting *within* the small-farm sector *increases* with farm size up to a certain level, economies of scale are apparently not linear at the tail end. It is found, however, that those smallest farms that did adopt actually allocated a higher share of their land to the new crop. Adoption and extent of adoption are thus not synonymous.

2. Increased income from formal off-farm employment—that is, relatively secure income from sources other than day labor—decreases the likelihood that households will grow export crops. The estimation result suggests that if this type of relatively secure income increases by Q500 (which is approximately the difference between the mean and standard deviation of FOFY), the probability of joining the scheme decreases by 4 percent.

3. An increased share of women's labor in total labor significantly reduces the probability of growing export vegetables (RWOMLAB) after controlling for total labor force of the household (LAB). As noted earlier, adoption of the new crop is primarily a male decision, and the model results suggest that households with a female-dominated labor force stay away from the new crop.

4. Traditional motivation to grow maize (HHTRAD) significantly decreases the probability of becoming an export crop grower.

5. For households located in a remote village that has recently been included in the scheme (village 1, San Matéo), the probability of becoming a member appears lower, while it is significantly higher in village 3 (Santa María Cauqué), which is located at the highway.

The statistically nonsignificant results in the probit model are also interesting to note:

1. Differences in land quality of the farm (WLQ) have not significantly affected the choice of becoming an export crop farmer.

2. Availability of household labor does not significantly affect the choice of becoming an export crop grower. The market for hired labor is highly integrated in the region, which suggests this model outcome.

3. The age and level of education of household head, which were assumed in order to indicate human capital endowment of the household, do not significantly affect the adoption probability.

In summary, it may be concluded from these results that the less traditional farmers on the somewhat larger (small) farms and those who do not have access to relatively secure (formal) off-farm employment were most likely to adopt the export crops.¹¹

¹¹ The probit model of the same specification was also estimated for the dependent variable defined as membership/nonmembership in the cooperative (= 1,0). While the results for the farm size and off-farm income variables were similar, the other variables were not statistically significant in that model.

That comparatively larger farms were joining the cooperative becomes clear from the distribution by farm-size class among the member and nonmember groups. Table 11 reveals a tendency often observed in patterns of adoption of "green revolution" technologies in peasant agriculture; more of the early adopters have somewhat larger farms (more than 1 hectare) than adopters who join later.

Profitability and Risks of New Export Crops and Subsistence Crops

For those farmers willing to adopt new export crops, the returns of those crops to factors of production (that is, land and labor) is central. In addition to the average profitability, the stability of returns from these crops is an important factor, as risk may be an issue of concern. Gross margins are used as measures of profitability. The gross margins calculated are based upon the 1985 survey covering the 1984/85 cropping season as expressed in the cropping calendar (Figure 4). Gross margins are the value of output minus the direct costs. Rent for land is not included. To assess the competitiveness of various crops at the farm level, gross margins are expressed per unit of land and per family-labor day.

Since snow peas stand out as the main new-crop in the following comparisons, its agronomic characteristics will be mentioned here. The peas are sown in rows. When they are about 20 centimeters high, the plants are tied to ropes that are stretched between sticks along the rows of plants. The plants grow up to about 1-1.3 meters on the continuously added ropes. The main work tasks are weeding, spraying for pest control, and picking the peas. Picking starts after an 8-week growing period and extends over 10-12 weeks. The crop is thus on the field from 18 to 20 weeks. Snow peas are sprayed two times per week over the growing period. The cost of recommended spraying in 1984/85 was Q596 per hectare. Because the devaluation of the quetzal on the parallel market sharply increased this cost (see Chapter 4), the 1986 spraying bill was 310 percent of the 1984/85 bill. The wage bill for snow peas is also considerably higher than for any of the competing crops. The related employment issues will be addressed later.

Being a legume (a variety of *p. sativum*), the snow pea enriches the nitrogen content of the soil, which benefits crops that follow in the rotation.

Snow peas yield a gross margin per unit of land 15 times higher than that of the principal subsistence crop, maize, on cooperative member farms (Table 12). Per unit of family labor, the gross margin of snow peas is about twice the margin reported for

Table 11—Farm-size distribution of cooperative members and nonmembers

Farm Size (hectares)	Nonmembers (percent)	Length of Membership		
		2 Years or Less	3-4 Years	5 Years or More
			(percent)	
Less than 0.25	25.8	5.0	6.1	2.8
0.25-0.50	36.0	20.0	24.5	20.8
0.50-1.00	21.3	47.5	40.8	41.7
1.00 or more	16.9	27.5	28.6	34.7
Total	100.0	100.0	100.0	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Figure 4—Cropping calendar of subsistence crops, traditional vegetables, and export vegetables in the Western Highlands, 1984/85

Crop	1984												1985						
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
Maize																			
Beans																			
Traditional vegetables ^a																			
Broccoli, cauliflower ^b																			
Snow peas ^c																			

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: The double lines show the main periods of planting, growing, and harvesting; the single lines show extended periods during which a minority of farmers engage in these activities.

^a Cabbage, carrots, radishes, and others.

^b Main planting season, May-August; main harvest season, June-September.

^c Main growing period, August-April; main harvest period, October-June.

maize, as snow peas absorb 7 times more family labor per hectare, or 5 times more total labor input in terms of days, than maize. Traditional vegetables are roughly as profitable as broccoli and cauliflower per unit of family labor. Beans are between maize and the above vegetables. The per hectare input costs of snow peas are about 13 times as high as those of maize. These high input costs of snow peas stem from high use of pesticides and from the costs of special production inputs (sticks to bind the plants and ropes to tie the climbing snow pea plants to the sticks).

Cooperative members finance the considerable input costs partly through agricultural credit. Forty-two percent of members had received credit during the previous year. On average the sum borrowed amounted to Q480, which covered the variable input cost for 0.3 hectare of snow peas. Only 3 percent of the nonmembers reported having had access to credit during 1984/85. It is interesting to note that those farmers who grow the new export vegetables under the cooperative scheme have higher returns and lower unit costs of production in the maize crop than other farmers (columns 1 and 2 of Table 12). The input cost and wage bill are higher for members, yet their output per unit of land is further increased, thus leading to this outcome. The relationship of this pattern to the export vegetables is analyzed in detail below.

The ranking of crops by their profitability shows a similar pattern if the sample is disaggregated by farm-size class (Table 13). There is a tendency for maize gross margins per hectare to decrease with increasing farm size, both for export crop producers and other farms, but returns to family labor do not differ a great deal between farm-size classes. Constant returns to family labor and decreased returns to land with increased farm size indicate that larger farms operate at higher cost levels per unit of land or at lower yield levels or both. No general tendency is visible from the tabulations of gross margins of the new export vegetables per unit of land and labor. The apparently negative scale effects for these crops, discussed above in the context of ALCOSA's experience (Chapter 4), may become effective only outside the range of small farm sizes observed in the sample.

Table 12—Cost of production and gross margins of export vegetables and subsistence crops, 1984/85

Item	Non-member Farms, Maize	Cooperative Member Farms				
		Traditional Crops			New Export Crops	
		Maize	Beans ^a	Traditional Vegetables	Broccoli, Cauliflower	Snow Peas
(quetzals/hectare, mean values of sample)						
Seeds, plants	0.20	0.21	26.55	106.30	85.76	54.87
Fertilizer	100.12	105.60	85.28	158.61	243.82	216.16
Other inputs	13.66	14.85	55.10	167.95	103.88	1,296.13
Total inputs	113.98	120.66	166.93	432.86	433.46	1,567.16
Wages paid	96.22	167.71	133.69	306.06	283.58	552.71
Value of output	353.75	457.80	681.00	1,804.53	1,339.17	4,416.20
Gross margin per hectare ^b	120.43	143.87	362.79	1,065.61	593.37	2,204.15
(days/hectare, mean values of sample)						
Days of family labor per hectare ^c	63	54	121	299	168	400
Days of total labor per hectare ^d	101	119	172	416	277	613
(quetzals/day, mean values of sample)						
Gross margin per day of family labor	1.91	2.66	2.99	3.47	3.53	5.51

Source: Computed from data from Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: The mean values are based on 173 observations on nonmember farms and 160 observations on member farms.

^a Beans in sole stand.

^b To compute the gross margin from value of output, wages, and total inputs, interest on the sum of purchased inputs and on the part of the wage bill for nonharvest labor is deducted. The interest rate used is 15 percent adjusted to the duration of the crop's growing period.

^c Men's, women's, and children's labor days are weighted by 1.0, 1.0, and 0.6, respectively.

^d This includes hired labor.

Cooperative members on average have higher returns than nonmembers to both land and family labor for the three comparable crops (maize, beans, and traditional vegetables; see totals in Table 13). In general, this pattern is also revealed within the farm-size classes.¹² Thus it appears that the more efficient farmers joined the export crop scheme, as there is no indication of basic differences in land-resource quality between the two groups. Yet, joining the cooperative may also have improved farmers' access to yield-improving technologies—for example, inputs and information. These aspects will be evaluated in more detail below. At this point it is worthwhile to note that export crop producers achieve higher returns to land and family labor from subsistence crops (maize and beans) than do other farmers, although the export crop farmers devote more resources to the new export vegetables.

The gross margin (net return) per day of family labor indicates the level of opportunity cost of family labor in agriculture. The gross margins per family labor day fall in the range of local wage rates, which were Q2.00-2.50 in 1984 and Q3.00-3.50 in 1985

¹² It should be noted that many different crops are aggregated into the group of traditional vegetables. The related gross margin figures vary considerably between farms due to this aggregation.

Table 13—Gross margins of export and traditional crops per hectare and per person-day of family labor, by farm size, 1984/85

Farm Size/Unit	Export Crop Producers					Traditional Crop Producers		
	Maize	Beans	Traditional Vegetables	Broccoli, Cauliflower	Snow Peas	Maize	Beans	Traditional Vegetables
(hectares)	(quetzals)							
Less than 0.25								
Per hectare	(188.00)	...	(407.00)	...	(2,198.00)	127.00	181.00	852.00
Per day ^a	(2.61)	...	(1.00)	...	(3.74)	1.98	3.18	1.64
0.25–0.50								
Per hectare	175.00	(254.00)	(2,654.00)	(365.00)	2,791.00	149.00	191.00	609.00
Per day ^a	3.13	(7.70)	(7.97)	(2.81)	6.10	2.10	3.19	2.14
0.50–1.00								
Per hectare	146.00	187.00	375.00	645.00	1,785.00	85.00	(25.00)	397.00
Per day ^a	2.43	2.25	1.24	3.41	4.52	1.42	(0.32)	1.15
1.00 or more								
Per hectare	117.00	648.00	860.00	624.00	2,398.00	84.00	83.00	935.00
Per day ^a	2.72	5.36	3.54	4.22	6.97	1.83	3.19	4.16
Total								
Per hectare	144.00	363.00	1,066.00	593.00	2,204.00	120.00	130.00	659.00
Per day ^a	2.66	2.99	3.47	3.53	5.51	1.91	1.76	1.96

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Values computed from 10 observations or fewer are in parentheses. The export crop producers are members of the cooperative; the traditional crop producers are not members.

^a Children's labor days are weighted with a factor of 0.6; men's and women's labor days are weighted with 1.0 each.

for a man's person-day in the field. Women's wage rates are reported to range from Q0.50 to Q1.00 lower than men's. Returns to family labor on export crop farms exceed these male and female wage rates by a substantial margin. As a result, the labor supply into the local labor market from these farm households has substantially decreased.

Inseparable from the assessment of profitability of new export crops versus traditional crops is their comparative risk. There is a great deal of uncertainty about the new crops' output and input price fluctuations. A long-term longitudinal study would be required to properly address the issue. Moreover, it should be reiterated that new export crops particularly impinge on the off-farm labor supply of small farm households in the Western Highlands. The comparison of risks in reallocating household labor away from the uncertain off-farm labor market into their own uncertain new crop enterprise is as important as the between-crop comparisons, which is the focus of most literature on farm production risk. While this study is not designed to assess this aspect, it should be kept in mind that the between-crop comparisons are of limited relevance for an agricultural system that is as closely integrated into the nonagricultural labor market as is the case with farmers in the Guatemalan highlands.¹³

A first indication of differences in degrees of price risk for crops is given by the variance of prices within a cropping year across the survey area. Clearly, average prices received by farmers for the new export crops vary much more than the maize price but not more than the price of beans and traditional vegetables grown for the local

¹³ Increasing labor market participation in case of crop loss is a common risk-adjustment strategy of small farmers in Central America. In a survey in El Salvador, it was found to be the most frequently used strategy. See Walker and Jodha 1985, 17-34.

markets. As shown below, the coefficients of variation of snow pea, broccoli, and cauliflower prices in 1985 tended to be even lower than those for beans and selected traditional vegetables.

<u>Crop</u>	<u>Coefficient of Variation</u>
Maize	0.23
Beans	0.83
Traditional vegetables	
Beets	0.77
Radishes	2.27
Lettuce	0.63
Spinach	1.00
New export crop	
Snow peas	0.58
Cauliflower	0.52
Broccoli	0.24

It should be noted, however, that the intrayear price differences of beans and traditional vegetables may be of a seasonal nature that could be predicted by farmers with a certain probability. Thus the level of uncertainty related to price variability of traditional crops may be less than, say, for snow pea prices, which do not follow a clear seasonal pattern (see discussion in Chapter 4).

A second indication of the risk of new export crops versus traditional crops is given by a comparison of the variation of their respective gross margins per hectare. We find that gross margins of the new export vegetables tend to be less variable across the sample than those of traditional crops.

Relative variability crop-by-crop does matter, but levels of potential losses as a proportion of the asset base (land) are also important for the determination of household risk. Given the high input levels for new export crops, the potential loss from crop failure, output-price depression, or input-price increases may constitute a much higher probability of substantial income loss. To assess this aspect, the frequencies and levels of losses from traditional crops and new export crops are evaluated. Losses are represented in this assessment by negative gross margins, that is, net returns to land and unpaid family labor were negative, as variable costs exceeded the gross value of production. A combination of factors may lead to this outcome; for example, unfavorable input-output ratios, high input or low producer prices, or both. From this comparison, it becomes evident that farmers produced the new export crops at a loss as frequently as the traditional crops in 1985.¹⁴ However, to take the two extreme cases—maize and snow peas—in 24.5 percent of the sample fields, gross returns of maize do not cover the variable costs and, similarly, in 25.1 percent of the fields, gross returns of snow peas do not cover these costs. The absolute loss per unit of land is about 10 times as much in the case of snow peas as it is for maize (Q130 versus Q1,309 per

¹⁴ It should be noted that the percentage levels of negative gross margins might be somewhat overstated due to the usual noisiness of such recall surveys that leads to extended tails of the distribution function of variables. For this analysis, only the *relative* comparison across crops is relevant, and that should not be affected too much by this problem.

hectare). Clearly, this new export vegetable appears quite risky if viewed in isolation on the farm, but most farmers tend to minimize loss by devoting only a fraction of their land to the new crop.

Losses and gains from crops within the farm enterprise may compensate for each other. A comparison between cooperative members and nonmembers shows that the percentage of farms that reported an overall income loss was similar in both groups in 1984/85 (17.8 percent of members and 16.8 percent of nonmembers). The income losses in percentage of total expenditures averaged 7.7 percent in the member households and 5.7 percent in the nonmember households. This suggests that overall income risk does not appear significantly greater among members than nonmembers.

Effects of New Export Crops on Land Use and Land Market

Despite the small absolute differences in farm size, cropping patterns change substantially by farm size. It is particularly interesting to note the case of maize. With increasing farm size, the share of maize in land use increases in member farms but decreases in nonmember farms (Table 14). Snow peas—the principal new export crop—have a relatively higher share in smaller farm-size classes of cooperative members. While the probit model (Table 10) indicated that the choice to become an export cropper is biased toward the somewhat larger farms within the small-farm sector, the relative scale at which new export crops are adopted (once the decision to grow them has been made) appears larger in the smaller farms (or at least the same as in the bigger farms if snow peas and broccoli-cauliflower are viewed together). It is noteworthy that some nonmembers of the cooperative also grow the new crops. They are mainly located in one village close to the Inter-American Highway, where traders have started to pick up export vegetables.

An effort is made in the survey to assess differences in land quality between member and nonmember farms. Farmers were asked to evaluate each of their fields according to a scale of 1 to 4 ("very good," "good," "not so good," "poor") in comparison with

Table 14—Cropping patterns of cooperative members and nonmembers, by farm size, 1985

Farm Size	Maize	Beans	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables	Other
(hectares)	(percent of cropland)					
Members						
Less than 0.25	35.3	3.2	44.9	...	14.5	2.1
0.25–0.50	41.4	5.0	28.9	8.4	13.5	2.6
0.50–1.00	45.3	6.6	27.7	13.0	5.2	2.3
1.00 or more	48.4	5.7	25.6	12.5	5.3	2.5
Total	46.7	5.2	28.0	11.1	6.7	2.4
Nonmembers						
Less than 0.25	67.7	13.1	5.8	...	12.4	0.5
0.25–0.50	60.0	19.0	4.8	1.8	11.0	3.4
0.50–1.00	60.7	14.2	7.0	4.1	12.7	1.3
1.00 or more	54.0	12.8	15.8	7.0	9.1	1.3
Total	66.1	11.7	6.3	2.5	11.4	1.9

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

the land quality in their community. A variable derived from this subjective evaluation, included in the probit model in Chapter 4, was insignificant for adoption. Although the distribution pattern of the surveyed fields by members and nonmembers (Table 15) underscores that there are no indications of substantial difference in land quality between member and nonmember farms, there is a clear indication that cooperative members grow the new export crops on their better pieces of land. The members planted new export crops on 69.2 percent of their land identified as "very good," but on only 31.6 percent of the land classified as "not so good."

The much higher returns of new export vegetables per unit of land, compared with traditional local vegetables or subsistence food crops, can be expected to impinge on the local land market. Demand for the quality land should increase, thus increasing land prices in the prevailing situation of extreme land scarcity. Given the shortage of cash and limitations of collateral for borrowing substantial amounts of money, the increased demand for land is hypothesized to be largely realized on the land-rental market rather than through land purchases. Yet, as the survey indicates, both the land-rental market and the land-purchase market appear to be stimulated by increased land demand from export crop growers. Cooperative members use a significant share of their rented land (20 percent) for the new cash crops (Table 16). Also, members pay higher rents per hectare of land used for new cash crops than for land rented and used for subsistence crops (rents per hectare are 42 percent higher for export vegetable fields). This may be due to the better land quality demanded for these crops.

Table 15—Relative quality of land of cooperative members and nonmembers and of land used for the new export crops

Land Quality	Share of Parcels in Each Quality Group		Share of Parcels Used by Members for New Export Crops
	Members	Nonmembers	
	(percent)		
Very good	10.2	7.2	69.2
Good	74.3	74.4	55.9
Not so good	14.9	17.6	31.6
Poor	0.6	0.8	0.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Table 16—Landownership of parcels and use for new cash crops

Land Status	Cooperative Members		Nonmembers Share of All Parcels
	Share of All Parcels	Share of Parcels Used for New Cash Crops	
	(percent)		
Owned	76	73	77
Rented	17	20	15
Other ^a	7	7	8

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Other forms of land acquisition, that is, temporary reallocations of land among members of a family.

Cooperative members expanded their own total land area during 1984 and 1985. Nonmembers had only a small increase. The reported net increase of members' land is 12.2 percent of the 1985 area compared with a 1.4 percent increase in the nonmember group. Land purchases are more frequent among the members, as 23 percent of the members reported a land purchase during the two years compared with only 8 percent for nonmember households. Usually very small amounts of land are purchased. Cooperative members were paying much higher prices for new land than nonmembers (Q6,272 versus Q3,150 per hectare). As in the case of rented land this may be due to the members' demand for more quality land for expansion of new export crop production versus the nonmembers' acquisition of more land for maize and beans.

Two conclusions are highlighted from this assessment of the effects of new export vegetables on the land market. First, the effective demand for land is increased as export crop producers expand their landholdings through rentals as well as land purchases. This expansion tends to further widen the existing gap in land size within the small-farm sector between export crop producers and other farmers. In the long run, it should be expected that a concentration of quality land will evolve in the sector of new export crop farmers, although currently there is no evidence of such a distinction.

Second, increased land values may be realized by land sales, renting out land, or making use of the increased collateral value of owned land on the capital market. Landowners in the area thus benefit from the increased land values induced by export crop production, regardless of whether they actually are export crop producers. Adversely affected through this effect are farm households that rent in land, especially if they have not taken up export cropping. Maintaining subsistence food levels from own production on rented land has become more expensive. The pressure to either give up rented land or join the export cropping scheme is increased due to the increased cost of land rental.

Effects of New Export Crops on Labor Demand and Employment

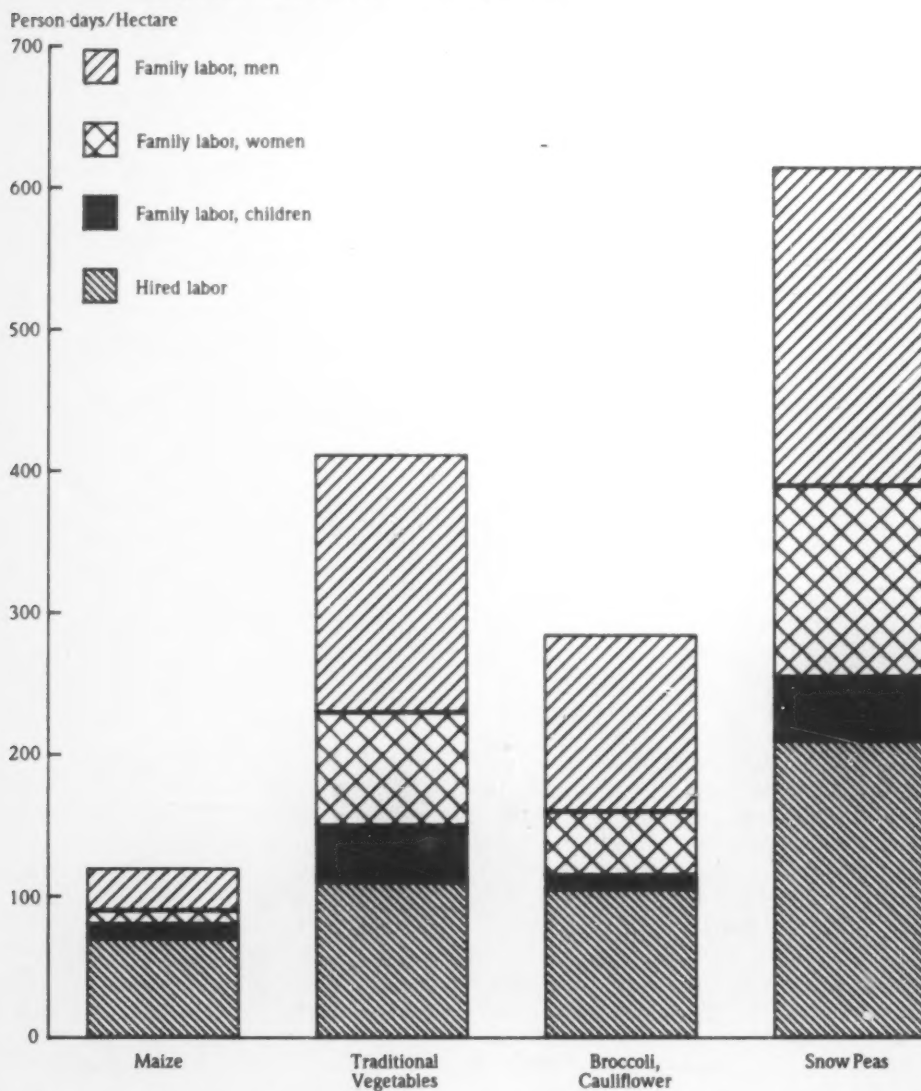
The new export crops create employment directly on the field and through forward and backward linkages, and indirectly through multiplier effects of the related income and employment. Their backward linkages are substantial. These crops have much higher input demands—not only for pesticides and fertilizers, which are not very labor intensive—but also, in the case of snow peas, for the locally manufactured sticks and ropes required for tying plants. Also, forward linkages are significant for employment, as the operation of the first stage of marketing is quite labor-intensive (selection, screening, and packing of produce). There are indirect employment effects from potentially higher income spent on goods and services with a high employment content. The following discussion focuses on the direct employment effects.

The new cash crops require much more labor input per unit of land than maize, the main subsistence crop (Figure 5). Snow peas also require more labor than traditional vegetables. Hired labor input is substantial, not only in the cash crops but also in subsistence maize, as more than half of the total labor input in maize is hired.

Most labor in all crops is provided by men, but this varies by crop type and by farm-size class. Women are responsible for 9 percent of family labor in maize, 25 percent in traditional vegetables, and 31 percent in snow peas (Table 17).

Family labor input per hectare decreases with increasing farm size for maize and traditional vegetables as well as for new export crops (Table 18). This family labor input is combined with increased hired labor inputs. Even in the smallest farm-size

Figure 5—Labor inputs for traditional crops and new export vegetables on cooperative members' farms, 1985



Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Table 17—Shares of men, women, and children in total family labor of cooperative members, by crop

Labor	Maize	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables
	(percent of family labor)			
Men	85	59	70	61
Women	9	31	20	25
Children	6	10	10	14

Source: Computed from Table 18.

classes substantial wage bills per hectare are incurred from new cash crop production (Table 19).

Division of family labor among men, women, and children in the production of new export crops is not uniform across farm size. As shown below, men's share of total family labor remains quite stable across farm-size classes, while women's share declines and children's share increases.

Farm Size (hectares)	Men	Women	Children
	(percent of family labor)		
Less than 0.25	59	39	2
0.25–0.50	59	33	7
0.50–1.00	58	32	10
1.00 or more	58	26	15

With increasing farm size women's labor is relatively replaced by hired labor and child labor. This is not true for men's labor. The high substitution between women's labor and hired labor is a phenomenon observed widely across countries of the Third World (see, for instance, Boserup 1970, 30). It is probably related to the increasing opportunity cost of women's labor in the field when the combined household and farm enterprise expands. Returns to female household labor, including such activities as meal preparation for hired labor, increase and lead to higher degrees of specialization within the farm-household. This still means that absolute levels of family labor input by both men and women may increase with increasing farm size.

The pattern of hired labor use changes with the introduction of new export vegetables. Cooperative members demand more hired labor for the subsistence crop (maize) on a per hectare basis than do nonmembers in the same farm-size class (Table 19). This demand for hired labor is a result of the inability of family labor to meet the increased demand of producing cash crops. The production level of traditional crops is maintained to a certain extent by hiring outside labor for their cultivation.

The direct employment effects of new export crops on farms can be approximately accounted for by tracing the partial effects due to (1) switching land between traditional crops and new crops, (2) the change in labor input per unit of land, and (3) related substitutions between types of labor input, that is, family labor (men, women, children) and hired labor. These changes of allocation of crops and labor differ by farm size. In a given farm-size class (i) the net employment effect (E) is then

Table 18—Average family labor used per hectare by cooperative members and nonmembers, by farm size and crop

Family Labor	Farm Size	Members				Nonmembers	
		Maize	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables	Maize	Traditional Vegetables
	(hectares)				(person-days/hectare)		
Men	Less than 0.25	64	350	...	271	53	399
Women		8	228	...	141	7	68
Children*		...	10	...	0	4	53
Total		72	588	...	412	64	520
Men	0.25–0.50	49	272	105	176	60	180
Women		6	152	25	100	6	69
Children*		1	34	0	57	5	36
Total		56	458	130	333	71	285
Men	0.50–1.00	50	231	133	181	52	249
Women		6	126	41	61	7	90
Children*		4	39	15	61	1	6
Total		60	396	189	303	60	345
Men	1.00 or more	37	200	104	167	42	169
Women		2	91	25	64	2	44
Children*		5	53	26	12	2	12
Total		44	344	155	243	46	225
Men	All sizes	45	234	117	181	54	239
Women		5	125	33	76	6	69
Children*		3	41	18	42	3	28
Total		53	400	168	299	63	336

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

* Children's labor input is weighted with 0.6.

$$E_i = \sum_j [\sum_s (a_{ijs}^* \cdot L_{ij}^* - a_{ijs} \cdot L_{ij}) + w_{ij}^* \cdot L_{ij}^* - w_{ij} \cdot L_{ij}], \quad (4)$$

where

a_{ijs}^*, a_{ijs} = per hectare labor input (days) of family labor types s ($s = 1, \dots, 3$) in crop j ($j = 1, \dots, 6$) and farm-size class i ($i = 1, \dots, 4$) with (a^*) and without (a) the new export crops in the production program,

w_{ij}^*, w_{ij} = per hectare wage labor input (days) with (w^*) and without (w) the new export crops, and

L_{ij}^*, L_{ij} = land used (hectares) for each crop (j) in farm-size class (i) with (L^*) and without (L) the new export crops.

While the situation of new export crops is represented by the situation of land and labor allocation in the cooperative member farms, the "without" situation is represented by nonmember farms of the respective farm-size class that do not grow the new crops. Participation in the scheme was found to be influenced by farm size and secure off-farm employment (see the probit model above). While the farm-size effect is accounted for by the disaggregation into farm-size classes, the effect of off-farm employment is not. One might suspect that cooperative member farmers were growing some of the more labor-intensive traditional vegetables before they switched to export vegetables. This hypothesis, which can be assessed by the small number of farmers who became members between the two surveys, is not supported. Therefore, the cross-sectional evaluation

Table 19—Wages paid for hired farm labor by cooperative members and nonmembers, by farm size and crop

Farm Size	Members				Nonmembers	
	Maize	Snow Peas	Broccoli, Cauliflower	Traditional Vegetables	Maize	Traditional Vegetables
(hectares)				(quetzals/hectare)		
Less than 0.25	135	158	...	...	95	141
0.25-0.50	159	469	149	128	65	73
0.50-1.00	143	618	249	350	122	438
1.00 or more	209	570	368	340	136	358
Average	168	553	284	306	96	165

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

of the employment effects appears reasonable. Table 20 presents the results of the above computations. The main findings are as follows:

1. Labor input in agriculture increases in the export crop-producing farms by 45 percent (81 days per crop season).

2. This increase is equally shared by family labor and hired labor.

3. The increased labor demand results primarily from snow pea production. On average, labor is cut back in maize by 7 days (13 percent), beans by 6 days (43 percent), and traditional vegetables by 12 days (29 percent), but total hired labor input into maize increases somewhat.

4. In the smallest farm-size class virtually all the net increase in labor input comes from family labor. Total labor input on these farms of less than 0.25 hectare more than doubles.

5. With increased farm size more hired labor is covering the increased work load, but in all four farm-size classes family labor input increases by a roughly similar absolute amount.

6. A substantial share of the increased family labor is from women—44 percent in the two smallest farm-size classes and 32 percent in the largest farm-size class.

The farm-level data can be used to extrapolate the employment effects to the six communities where the cooperative is operating. For 1985, the increased labor demand in crop production corresponds to about 15 percent of agricultural employment. When added to the employment in input supply (special input shops in the villages and special production inputs for snow peas) and output marketing (cooperative staff), it yields an increase in agricultural employment of 21 percent.

Clearly, the employment effects are significant and impinge on off-farm employment and interregional migration in the location. Among export crop producers an average of 0.72 persons per household work away, compared with 0.92 family members among the other sample farmers. Also, nonmembers of the cooperative spend more time away over the year (4.2 versus 2.3 months on average).

The increased demand for hired labor in the region spreads the employment effect. Much of the hired labor comes from neighboring communities where export crop production has not been introduced.

Effects of New Export Crops on Staple Food Production

The evaluation above shows that new export vegetables yield higher returns per unit of land and labor than subsistence crops. Yet cooperative members still plant on

Table 20—Direct employment effects of the new export vegetables, by farm size

Farm Size/ Labor	Change in Labor Input Due to Shifts in Crop Area and Reallocation of Labor						Total
	Maize	Beans	Traditional Vegetables	Other Crops ^a	Broccoli, Cauliflower	Snow Peas	
(hectares)	(person-days of work/year/farm)						
Less than 0.25							
Family	-4	-2	-2	+1	...	+57	+50
Hired	0	0	-5	0	...	+6	+1
Total	-4	-2	-7	+1	...	+63	+51
0.25-0.50							
Family	-11	-6	+4	0	+2	+61	+50
Hired	+5	-2	+2	+2	+2	+26	+35
Total	-6	-8	+6	+2	+4	+87	+85
0.50-1.00							
Family	-9	-6	-15	+1	+7	+58	+36
Hired	-4	-1	-1	-4	+1	+42	+33
Total	-13	-7	-16	-3	+8	+100	+69
1.00 or more							
Family	-9	+2	-11	+3	0	+62	+47
Hired	+9	-5	-10	+7	+15	+42	+58
Total	0	-3	-21	+10	+15	+104	+105
All sizes ^b							
Family	-9	-4	-9	+1	+3	+59	+41
Hired	+2	-2	-3	+1	+5	+37	+40
Total	-7	-6	-12	+2	+8	+96	+81

Source: Computed from data from Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Includes tree crops and fruits.

^b Weighted by the distribution of farm-size classes.

average half of their land with maize and beans. Although this is significantly less than nonmember farmers, it is still a large proportion. No obvious technical reason exists why farmers should not further expand their export vegetable area, as suitable land remains in reserve (Table 15). Hired labor is available in the region to fill increased labor demand. In the smallest farms, underemployed family labor or family labor seeking off-farm employment could be drawn into the export crops, since average returns per workday are much higher than the prevailing market wage rate (Table 13). This production behavior can be hypothesized as driven by the concern of farmers about risk of the new crops (the potentially high absolute losses per unit of land were discussed above) and the household's desire for food security.

A household is in a secure food situation when it always—throughout the seasons and over the years—has the ability to acquire the food needed to maintain the health of all its members. In farm households, household-level food security may be achieved by own food production and related stockholding, or by relying on open-market trading of food and nonfood production to generate income (and savings), or partially by seeking off-farm, income-earning possibilities. The level and mix of these alternatives depend upon a household's resource endowments, including human capital; the type of market integration for agricultural produce, food, and labor; and the extent to which public institutions (intervention schemes) or community-level institutions (villages, extended family) play a role in providing basic levels of food security in view of unforeseeable circumstances. It is obvious that with decreased institutional provision of food security, lower security of off-farm employment opportunities, and more instability of the agricul-

tural produce and food market, the food security burden shifts toward own production and stockholding. The historical record of food security in the Western Highlands suggests that these are the driving forces that lead farm households to maintain high levels of staple food production for direct household consumption. The survey region as a whole is, however, not self-sufficient. About 50 percent of maize consumed in the six survey villages consists of net imports into the region (Table 21). Self-sufficiency in maize is 67.7 percent among cooperative members and 53.4 percent among nonmembers.

Public institutions cannot ensure effective response to household or local crisis situations. The food and agricultural produce markets are very unstable, as is the labor market. It can thus be hypothesized that farm households operating below or at the margin of food security provided from own food production put a risk premium on nonfood income-earning alternatives. This risk premium—or food insurance premium—that farm households are indirectly paying is represented by the difference between the actual market price of staple food and the shadow cost of production of staple food at the margin. Clearly, the shadow cost of staple food production increases when the opportunity costs of land and labor increase as a consequence of introduction of a new cash crop that yields higher returns to land and labor. To what extent this occurs in the case studied here will be evaluated with a farm model later in the chapter. Before this normative aspect is discussed, another question will be addressed: What actually happened to food production when the new export vegetables were introduced?

Practically all export crop producers (94 percent) maintain some maize production. Ninety-seven percent of the other sample farmers grow maize. Farm households were asked in the 1985 survey what the three most important reasons are for them to grow maize. By far the most important reason stated was "to always have food" (Table 22). Differences between export crop producers and other farmers are small in this respect. The second most important reason, tradition ("we always did it like that"), was followed by the perception that "other crops are risky" and the statement that "maize is profitable." Much has been written about traditional and religious motivations of Western Highlands farmers for growing maize.¹⁵ While most farmers do not give up their *milpa* (cornfield) and plant it with something else altogether, their attitude toward maize and its importance in the production program obviously undergoes change. The introduction

Table 21—Consumption of own production and net purchases of maize in cooperative member and nonmember households, 1985

Households	Consumption of Own-Produced Maize*	Net Purchases of Maize
	(percent of maize consumption)	
Cooperative members	67.7	32.3
Nonmembers		
Farmers	53.4	46.6
Nonfarm households	...	100.0
Weighted average for the six cooperative villages	50.4	49.6

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

* Excluding use for animal feed.

¹⁵ A comprehensive piece is, for instance, Bossen 1984; insights are also provided by Gladwin 1983, 146-147.

Table 22—Farmers' attitudes toward growing maize

Stated Reason for Growing Maize	Ranking of Reasons					
	Cooperative Members			Nonmembers		
	Most Important	Second	Third	Most Important	Second	Third
	(percent of responses)					
To always have food	84	10	2	86	11	...
We always did it like that	3	57	15	1	57	19
Other crops are risky	1	7	16	...	8	12
Maize is profitable	...	2	9	...	5	6
Other	9	12	7	11	10	7
Not applicable	3	12	51	2	9	56

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

of new export crops plays a role in this context, and at the same time, the adoption of new crops is affected by these attitudes. This was already apparent in the adoption model (Table 10) and is further revealed when the reasons stated for growing maize are compared for early versus late adopters of new export crops. Long-term members of the cooperative are more concerned about own-produced maize supply than are new members (Table 23). Also, the early adopters have been or have become less traditional in their decisionmaking on production; the importance of tradition decreases with duration of membership in the cooperative. Long-term members also view other crops as less risky than do new members.

This change in attitude patterns does *not* lead to a reduction in maize availability from own production for consumption. In fact, when corrected for farm size, the majority of export crop growers tend to have similar or higher amounts of maize available for consumption from own produce than other farmers (Table 24). Despite reductions in area and labor inputs to maize, household-level production is maintained because of higher yields of the staple food per unit of land. Cooperative members' maize yields are 30 percent higher on average than those of nonmembers (Table 25). However, because of higher shares of land use for beans, the nonmembers have in the aggregate a somewhat greater subsistence-food availability (maize and beans together) than the members.

Table 23—Reasons for growing maize stated by farmers, by duration of cooperative membership

Reason ^a	Years of Membership in Cooperative		
	More than 5 Years	3–5 Years	Less than 3 Years
	(percent)		
To always have food	92	89	82
We always did it like that	51	62	64
Other crops are risky	9	20	23

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^aOne, two, or three reasons could be stated; therefore, the percentages do not add up to 100 (see Table 22).

Table 24—Production of subsistence maize and use for consumption in farm households, 1985

Farm Size (hectares)	Cooperative Members		Nonmembers	
	Production	Used for Own Consumption ^a	Production	Used for Own Consumption
		(kilogram/adult equivalent) ^b		
Less than 0.25	48	41	59	49
0.25–0.50	103	88	95	82
0.50–1.00	131	113	127	97
1.00 or more	182	137	180	138
Average	142	115	109	87

Source: Computed from data from Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Calculated from a complete production and disappearance balance (production minus sales, losses, animal feed, gifts, seed).

^b Adult equivalents are based on calorie requirements of persons in the household by age and sex.

The two surveys of the same farms permit a comparison of farmers' maize yields once they had moved from nonmember to member status and from recent to long-term members. Maize yields were substantially higher in 1985 than in 1983 in all groups. Climatic conditions played a role in these yields. As shown below, the increase was highest in the group consisting of cooperative members who had joined 3 to 4 years earlier and above average in the group who had joined 5 to 6 years earlier.

Status of Group	1983-85 Change in Kilograms per Hectare
Nonmembers in 1983 and 1985	+ 272
Members since 1984 or 1985	+ 45
Members since 1982 or 1983	+ 456
Members since 1980 or 1981	+ 314

By far the lowest yield increase is in the group of cooperative members who had joined most recently. Their yield increase is even below that of nonmembers. This pattern gives some insights into the dynamics of maize yields in the context of increased export crop production: initially, yields per hectare stagnate or may even drop when the farmer gives much of his attention and resources to the new crops, thus pushing maize onto the more marginal land of his farm. A couple of seasons later, maize yields apparently do catch up. Appropriate program and policy packages that help farmers to speed up in catching potential positive spillover effects from new cash crops to subsistence crops may have high returns and assist in ensuring against household-level food insecurity.

A combination of factors is responsible for the maize yield increases among cooperative members. Fertilizer inputs increased by an average of 6 percent and cropping practices are more labor-intensive among members. Total labor input to staple foods decreases, but labor input per unit of land is increased by 18 percent (mostly for more weeding). Much of the additional weeding labor is hired. Despite increased inputs (fertilizer) and labor, cooperative members produce maize at lower average cost per unit of output. When the cost of family labor is estimated with the prevailing wage rate, members produce a ton of maize for Q189, while nonmembers produce a ton for Q214. Thus, members appear to be more efficient—whether they were so before

Table 25—Yields of subsistence food crops on cooperative member and nonmember farms, 1985

Farm Size	Cooperative Members		Nonmembers	
	Maize	Beans	Maize	Beans
	(metric tons/hectare)			
Less than 0.25	(2.3)	(1.1)	1.8	0.5
0.25–0.50	2.4	(0.7)	1.7	1.5
0.50–1.00	2.1	1.2	1.5	0.6
1.00 or more	2.2	1.8	1.7	0.8
Average	2.2	1.3	1.7	1.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Figures based on less than 10 observations are in parentheses.

joining the scheme or became more efficient through joining the scheme is an issue addressed in more detail below. Both of the above cost figures come close to the prevailing farmgate selling price of maize, which was Q210 on average in the 1985 sample period. Average costs are not much different from marginal cost in this production system.

A closer look at the subsistence crops-export vegetable interaction is provided in the following production function and a programming-model analysis. The objective of this analysis is to assess *competition and complementarity* between the new crops and the subsistence crop (maize) in particular. The approach will be briefly described at the outset.

Crop production (q) is technically a result of area (a) times yield (y) of a crop (i):

$$q_i = a_i \cdot y_i. \quad (5)$$

Choices on the use of inputs, technology, and the amount and quality of land for a certain crop are joint decisions. Acknowledging the problem of separating these decisions, competition between crops can be built into an area allocation function, while input-output relations may be assessed on a per unit of land basis in a yield function.

$$a_i = b_{ij}X_j, \text{ and} \quad (6)$$

$$y_i = b_0 + b_{im}X_m, \quad (7)$$

where b_{ij} and b_{im} are the parameters of the area allocation and yield function of the respective exogenous variables X_j and X_m . While the X_j in the area allocation model is mainly describing economic environment and depicts the related response of farmers, the X_m in the yield model covers technical input-output relationships.

It is hypothesized that consumption needs (calorie requirements) determine, among other things, that the traditional farm households plant a certain share of their total area with maize. With increased farm size, this "subsistence needs-oriented" determination of the maize area is reduced. The worse the land quality of a farm, the higher the share of land required for maize for subsistence needs, everything else being equal. It is also hypothesized that a more traditional attitude toward maize would lead to an increased share of maize land.

Maize is only to a minor extent a "cash crop," but its area share should be expected to be affected by the relative returns to maize versus new export vegetables after desired subsistence levels are fulfilled along the above-stated hypotheses. It is also expected that membership in the cooperative leads to a decreased maize area share beyond the above-mentioned factors, as the cooperative stimulates the growing of new crops. Finally, village-specific dummy variables are included in the model, since the land-quality variable is based on village-specific comparisons of farmers and not on a generalizable measure.

The estimation results of the area model specified along these hypotheses are in Table 26. The model explains a high share of the variance in maize area allocation (85 percent). The following findings will be highlighted:

1. Production is very much driven by staple food needs; this becomes evident from the highly significant variable representing the calorie requirements of the household (ACU). One additional adult-equivalent unit in the household leads, all else (including farm size) being equal, to an expansion of the maize area share by 6 percentage points. Clearly these semisubsistence households not only (partly) consume what they grow but also base their maize production decisions on consumption requirements.

2. Households with a more traditional attitude toward maize (DMZREAS) have a higher maize area share, but smaller farms plant relatively less area with maize (FSZHA). Both determinants are statistically highly significant.

Table 26—Area allocation to maize and the effects of export vegetable production: regression model

Variable	Parameter	t-Value
DCID5	0.03370	0.647
DCID4	0.09424	1.855
DCID3	-0.03591	-0.892
DCID2	0.12100	2.391
DCID1	0.11986	2.454
RGM	-0.04209	-1.075
MZLANDQ	0.18134	16.542
FSZHA	-0.06416	-2.792
DMZREAS	0.06791	2.238
ACU	0.06005	10.189
MIEM	-0.04272	-1.509

$R^2 = 0.85$, $DF = 337$

Notes: Dependent variable: maize area over total farm size.

- DCID1 . . . 5 = dummy variables for villages 1 through 5 = 1, else = 0;
- RGM = ratio of gross margin of new export crops over gross margin of maize;
- MZLANDQ = quality of area under maize (1, . . . , 4; 1 = best);
- FSZHA = farm size in hectares;
- DMZREAS = traditional attitude toward maize = 1, else = 0; 1 = "we grow maize for own consumption because we always did it like that";
- ACU = calorie requirements of households (adult equivalents); and
- MIEM = membership in the cooperative = 1, else = 0.

3. The worse the land quality (MZLANDQ) the bigger the area share of maize. This is to be expected, as alternative crops have less comparative advantage on such land and households also have absolute targets of maize supply from own production.

4. Cooperative membership (MIEM) tends to decrease the area allocated to maize as expected; the net effect is about 4 percentage points, thus, all else being the same, maize area decreases from 60 to 56 percent. The respective parameter is not highly significant.

5. The ratios between the gross margins of maize and the new export vegetables do not turn out to be significant (RGM). It is probably only in the long run that their obvious role comes into play significantly.

Maize yield models are estimated for the total sample (model 1) and separately for the cooperative member farmers (model 2). Finally, yield model 2 is modified by including the degree of participation in export crop production to assess its effects on maize yields beyond the common production factors (model 3).

A heuristic approach is taken to specification of the yield models. From increased fertilizer use, higher yields are expected though decreasing at the margin. Increased labor input should have positive yield effects. With better education, farmers are expected to make more efficient use of resources and get higher yields. On smaller farms, it is hypothesized, farmers pay more attention to yields beyond the factors mentioned. Yields are expected to be lower on plots of lower land quality.

The estimation results of the yield models formulated along these hypotheses are in Table 27. The main findings of this analysis are as follows:

Table 27—Maize yields and effects of export vegetable production: regression models

Variable	Total Sample		Cooperative Members Only			
	Model 1		Model 2		Model 3	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
DCID5	382.65000	1.729	621.41000	1.844	505.53500	1.512
DCID4	-65.68800	-0.298	23.72200	0.075	67.34400	0.217
DCID3	-6.77190	-0.039	-48.71030	-0.183	-56.24500	-0.215
DCID2	-824.29200	-3.886	23.72290	0.075	-877.94900	-2.527
DCID1	-40.26500	-0.195	513.74800	1.390	-58.24500	-0.215
MZLANDQ	-136.25200	-2.196	-34.01890	-0.265	68.67100	0.518
HHEDUC	33.77700	0.933	155.39500	2.645	162.74200	2.815
LABDAYS1	2.20680	2.081	4.07790	2.517	3.69015	2.307
RAREA34	...	...	...	...	811.23180	2.506
FSZHA	-17.92300	-0.186	-70.33560	-0.482	35.65770	0.238
INPUT1	9.81776	4.021	9.48170	2.144	8.14740	2.095
SQINPUT1	-0.02326	-2.973	-0.02451	-1.820	-0.02445	-1.848
(constant)	1,256.55000	4.449	834.56600	1.873	383.55100	0.810
	R ² = 0.19		R ² = 0.20		R ² = 0.23	
	F = 7.02		F = 3.40		F = 3.75	
	DF = 326		DF = 148		DF = 147	

Notes: Dependent variable: maize yields in kilogram per hectare, 1985.

- DCID5 = dummy variables for villages 1 through 5 = 1, else = 0;
- MZLANDQ = quality of area under maize (1, ..., 4; 1 = best);
- FSZHA = farm size in hectares;
- HHEDUC = years of schooling of head of household;
- LABDAYS1 = total labor days in maize per hectare;
- RAREA34 = area under new export vegetables over total area (ratio);
- INPUT1 = cost of fertilizer per hectare of maize; and
- SQINPUT1 = cost of fertilizer per hectare of maize (squared).

1. Input levels of fertilizer (INPUT1) increase yields as expected, and at decreasing rates as the negative sign of the squared term indicates (SQINPUT1). Fertilizer cost per hectare is used as a proxy for nutrients. Differences between the cooperative members and the total sample are not significant in this respect. One additional quetzal spent on fertilizer yields—calculated at sample means—4.9 kilograms of maize at the margin, which sold for Q0.98-1.23 on the market.¹⁶ This suggests that fertilizer use is in the range of efficient levels.

2. Increased labor inputs (LABDAYS1) have a higher than average positive yield effect on cooperative farms. Although marginal labor productivity in maize is higher among members than for the total sample, marginal returns to labor of Q0.82-1.02 (model 2 with maize price of Q0.20-0.25) in the subsistence crop are at the lowest end of the prevailing wage rates, which were Q2.00-2.50 per day in 1984 for men and Q1.00-2.00 for women.

3. A striking result is that better education significantly shifts the yield function upward in the group of cooperative members but does not do so in general (model 2). Apparently literacy becomes increasingly more relevant for productivity when the farms become more complex with the new export crops included in the production program than it does in general (model 1). This is fully in line with the finding of the specific study on the effects of education on Guatemalan agriculture (Freire 1981, 107-145) that illiterate and literate farmers operate on the same aggregate production function, but literate farmers are technically more efficient than illiterate farmers on more diversified farms.

4. Land quality (MZLANDQ) tends to affect yields as expected; here it becomes clear that separating the area allocation effect from the yield effect of production is useful, as the effect of land quality works in opposite directions in the two functions of the model.

5. A striking effect results from the new export vegetables in the crop production program (RAREA34): the higher the share of new crops in the land use, the higher the maize yields even after accounting for different levels of inputs, labor use, and human capital (model 3). Two explanations for this result come to mind. First, the snow pea crop increases the soil-nitrogen levels, which benefits maize if maize follows in the rotation on that land. Second (and more hypothetical), export crop producers improve crop management, which leads to higher efficiency in input use in maize. This effect is then not captured in the input and labor variables. It is plausible that export vegetable producers, in their desire to increase yields of maize for the purpose of maintaining household food security, eliminate Leibensteinian "x-inefficiencies" tolerated before (Leibenstein 1966). The parameter estimated in the yield function implies that joining the scheme with average allocation of land to the new crops (RAREA34) results in a yield increase by 11 percent above the result from higher fertilizer input and labor use per hectare. The higher yields among cooperative members are to this extent a result of the complementary interaction with the new export crops and not just a result of inherently higher efficiency of members.

To sum up, the analysis on the basis of area and yield functions for the subsistence crop (maize) shows that new export vegetables play a complementary rather than a competitive role in the system. Although maize area is reduced and partly squeezed onto land of lower quality, increased input use (fertilizer and labor), favorable soil-fertility effects of the main new crop (snow peas), and more efficient crop-production practices

¹⁶ Maize prices ranged between Q0.20 and Q0.25 per kilogram in the 1984/85 crop year.

overcompensate for the adverse effects and leave export crop producers with higher yields and total supply levels of the subsistence crop. This finding is in line with findings by Reyes-Hernandez, García, and Campos (1985), who diagnose positive yield-increasing spillover effects for the traditional food crop (maize) in more diversified farm-production systems in the area of Chimaltenango (Western Highlands). In their small sample of farms, maize yields in the diversified systems were about 40 percent higher than in the traditional system.

A Premium for Own-Produced Maize: Model Results

The context in which this interaction between new export vegetables and subsistence crops takes place is not only the field crop operation of the farm enterprise but the farm production-consumption unit. To evaluate the effects of introduction of the new crops on farm households' incentive to provide food security from own production, a linear programming model is constructed.¹⁷ Applying a programming model with a profit-maximizing objective function under constraints does not imply an assumption that the farm households in the Western Highlands are single-minded, short-term profit maximizers. It is recognized that a multitude of objectives exist for farmers that may be only partly captured by the constraints introduced into the model. All evidence from the evaluation of response to crop profitability, however, suggests that small highland farmers are managing their agricultural resources and their own time very efficiently and rationally in an economic sense. Still, opposite conclusions have sometimes been drawn for the highland farmers. Gollas (1977), for instance, concludes (from a Cobb-Douglas production function analysis with results that show a positive marginal productivity of farm labor in view of an assumed general surplus labor situation) that the highland farmers are "poor and inefficient." More careful production function analyses by Marsh, Jameson, and Phillips (1983) and Stein (1982) as well as the assessment of households' flexible response to returns to time inside and outside agriculture by Swetnam (1980) clearly refuted Gollas's "poor and inefficient" conclusion for the traditional farmers of the highlands.

Although only a small proportion of farm households sell subsistence crops (13 percent of all maize producers in the sample sold maize during the year), almost all farm households grow maize for own consumption. The cost of this maize to the farm household is determined by the opportunity cost of the resources used for its production. Obviously the opportunity cost of maize production increased when farmers had the option of growing snow peas. It thus follows that consumption of own-produced maize should have become more costly. To what extent is this actually the case? How did farmers respond to this change in this key shadow price?

The model is based on average data of the 0.50-1.00 hectare farms in the sample. Three versions of a farm model are used for comparative static analysis: model 1 represents the situation before new export crops were introduced; model 2 represents the situation after export crops were introduced, but yield levels and technology in subsistence crops are not changed; and model 3 represents the situation as in model 2, but with actual improved productivity in subsistence crops.

The three model versions are described in the Appendix. The main features of the model are the usual constraints on land and family labor (by season). Inputs (fertilizer, pesticides), hired labor, and input financing are available at exogenously fixed prices.

¹⁷ Average data from the 0.50 hectare and 1.00 hectare farm-size classes are used for the model's coefficients.

Rotational restrictions follow the ones widely accepted by farmers. In all three model versions, household demand for staple food (maize or beans or both) is maintained at the same level as observed in the respective class of sample households. Family labor of men and women—but not children—may also earn income from off-farm employment at a constant wage rate.

In the initial situation (model 1) the shadow cost of maize produced for own consumption is Q0.49 per kilogram (Table 28)—more than twice the average sales price of maize in the respective survey year (Q0.21) and substantially higher than the average purchase price (Q0.26). Clearly, farm households are willing to pay the price in terms of income forgone to have maize from their own fields. The difference between the shadow cost of maize production for own consumption and the actual purchase price of maize can be interpreted as a "food-security insurance premium." In 1985 the premium was Q0.23 per kilogram in farm households that did not grow the new export vegetables. When the new export crops become an option for the farm household, this insurance premium increases drastically—nearly quadrupling, as demonstrated with model 2 versus model 1 (from Q0.23 to Q0.90 per kilogram). Maintaining subsistence production becomes more than twice as costly as before: the shadow cost of maize production increases from Q0.49 to Q1.16 per kilogram. While there was an incentive before, as indicated by the 1985 insurance premium, to bring down the unit cost of production for subsistence, this incentive was much increased by the introduction of competitive export vegetables.

Households have two options in responding to the increased cost of food security provided from own production. They may simply cut back the staple food production or increase its productivity (or a combination of the two). The yield function analysis above demonstrated that they most often choose the latter. This option's effect on the

Table 28—Effects of new export vegetables on shadow cost of subsistence food production and selected other variables

Variable	Model 1	Model 2	Model 3
		After Introduction of New Export Crop	
		Without Improved Productivity in Subsistence Crops	With Improved Productivity in Subsistence Crops
Land use (hectares)			
Subsistence crops	0.49	0.49	0.35
Traditional vegetables	0.26		
Snow peas	...	0.26	0.40
Family labor			
On-farm } (days in model 1 = 100)	100.00	124.00	165.00
Off-farm }	100.00	84.00	55.00
Share of family labor on farm (percent)	49.30	59.60	75.00
Working capital			
Over year (quetzals in model 1 = 100)	100.00	304.00	441.00
In percent of cash income	24.50	51.40	58.10
Shadow price of land (quetzals/hectare)	456.00	1,455.00	1,455.00
Shadow cost of maize produced for own consumption (quetzals/kilogram)	0.49	1.16	0.84
Difference to average maize purchase price (quetzals/hectare) ("insurance premium")	0.23	0.90	0.58

Notes: These results of programming model scenarios are for an average 0.75-hectare farm based on 1985 survey of farms from 0.50 to 1.00 hectare. See Appendix for descriptions of the three versions of the model.

insurance premium is traced in model 3. Clearly, the cost of maintaining desired household food security through production of staple food for own consumption can be substantially decreased this way (from 0.90 to 0.58, as shown in Table 26). Still, the insurance premium remains higher than in the situation at the outset. The incentive remains high to further increase productivity in staple food production.

The new crops lead to an increased labor and capital intensity in agricultural production. The new export crops require not only more absolute working capital but also more relative capital in percent of total household cash income. Without new export crops, working capital invested in crop production was about one quarter of total cash income (model 1). With the new crops, it amounts to more than half of cash income (58.1 percent, model 3).

With increased productivity of staple food, overall income increases and land is freed for the new export crop that can generate additional income. The income increase made possible by increased productivity of subsistence crops (going from model 2 to model 3) is about as high as the income effect from the pure introduction of the export vegetables without improved productivity in the staple foods (going from model 1 to model 2). This key role of technological improvement in staple food production of farms that have the option of growing new export crops must be understood in order to maximize both income and employment opportunities.

In summary, the following conclusions are stressed from this analysis of the agricultural production effects:

1. Export crops and subsistence crops are complementary rather than competitive in the case studied.

2. Household-level food security through a high level of subsistence food production was maintained or even expanded when new export crops were introduced. While this is understandable and explainable with market failures—that is, failures in the food market and in the labor market on which many of the small farmers with an excess supply of labor depend—this approach to food security does not appear to be the “first-best” economic solution, as indicated by the high “insurance premiums” paid by farm households for own-produced subsistence food. A policy environment that ensures the functioning of food markets without major disruptions is a precondition for farm households to develop confidence in the market and consequently to make use of the advantages of the exchange economy. It is thus a precondition for first-best economic solutions to food insecurity. Options other than food security based on own-produced food exist for the cost-effective provision of food security; for instance, food-related income transfers or employment-oriented measures targeted toward the absolute poor. Such measures would impinge on the observed resource allocation in agricultural production biased toward staple food only if they were perceived as reliable by the poor.

3. The shadow cost of staple food production for own consumption increases drastically as returns to land and labor of the new export crops increase. In view of the prevailing high preference for having maize from the own field for food security reasons, the increased shadow cost of subsistence production did lead to some reduced area allocation to staple food production. However, variable inputs (labor, fertilizer) per unit of land increased. This and positive yield-increasing effects of the new crops in the rotation permit reduction of staple food crop area along with an increase in food output combined with the favorable income and employment effects of the new crops.

4. The Western Highlands farmers were able to adopt this balanced strategy of crop diversification plus intensification of staple food production because of the availability of yield-increasing measures, related input supply channels (seed, fertilizer), and hired

labor. In the absence of these conditions, farmers with strong preferences for subsistence crops will not adopt the export crop. The policy conclusion is obvious: if gains from diversification and export crop production are to be achieved through rapid adoption by small farmers without diminishing their food security in an environment of market failures, farmers must have access to technology to enhance food crop productivity per unit of land.¹⁸

Effects of New Export Crops on Off-Farm Income

The previous chapters concerned production and related income effects. As stated earlier, agricultural income is very much complemented by income from other sources in these communities of the Western Highlands. In fact, it is often the other way around: off-farm income is complemented by farm income in many households.

Patterns concerning sources of income differ by cooperative status (Table 29). In general, nonmembers earn more income as agricultural day laborers and nonagricultural workers than do members. Member households are also active in such off-farm income-earning activities during the year, but they work fewer days off-farm, which explains their lower absolute income from these sources. In addition, income from transfers and remittances is not only higher on average in member households but also more widely distributed. Seventy-five percent of the households reported transfers.

The distribution pattern of income by source suggests that export crop producers withdraw from the off-farm labor market and spend more of their time in agricultural production on their own fields (see also employment effects in Table 20). This reduces

Table 29—Percentage of households receiving income from off-farm activities, by farm size and cooperative membership

Farm Size/ Membership	Source of Off-Farm Income			
	Agricultural Day Labor	Nonagricultural Wages	Nonagricultural Merchant	Transfer Income, Remittances
(hectares)	(percent of households in farm-size group)			
Less than 0.25				
Members	25.0	50.0	12.5	62.5
Nonmembers	53.2	48.9	10.6	55.3
0.25–0.50				
Members	25.0	33.3	13.9	75.0
Nonmembers	40.6	48.4	17.2	57.8
0.50–1.00				
Members	17.8	27.5	19.2	76.7
Nonmembers	13.2	34.2	28.9	57.9
1.00 or more				
Members	7.5	28.3	11.3	75.5
Nonmembers	30.0	20.0	6.7	36.7
All sizes				
Members	16.5	30.0	15.3	75.3
Nonmembers	36.3	40.8	16.2	53.6

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

¹⁸ Similarly, in labor-scarce, land-rich environments, such as parts of Africa, productivity of labor in food production must increase to achieve this desired development effect.

their off-farm earnings. Numerous intervening variables determine the extent to which this actually happens. The following model sheds some light on this.

It is hypothesized that household earnings are determined by available labor; demographic structure; the farm's resource base in relation to household labor force, which determines the opportunity cost of off-farm work; and human capital, which may impinge on the off-farm income-earning possibilities. Local-level labor market conditions, including location of village, may further differentiate the effect of the various factors. An off-farm income-earning function (r) may thus be specified for i households as

$$r_i = a_0 + b_j X_{ij} + b_k X_{ik} + u_i, \quad (8)$$

where

a = intercept,

b_j = the parameters of X_{ij} variables describing the off-farm income-earning potentials,

b_k = the parameters of X_{ik} variables depicting the on-farm income-earning potential, and

u_i = error term.

The results of the model specified along the above-stated hypotheses underscore that off-farm income-earning by farm households is reduced with an increased resource base for agricultural income-earning on the own farm (RFMLAB) (Table 30). The opportunity to grow the new export vegetables with rising returns per unit of family labor can be interpreted as an expansion of the resource base per unit of family labor. Returns to family labor more than doubled those of traditional crop producers and export crop producers (for instance, maize, beans, and traditional vegetables of traditional farmers versus snow peas, broccoli, and cauliflower of export crop producers shown in Table 13). A doubling of the resource base (land per family labor, RFMLAB) would reduce off-farm income-earning by 11 percent at sample means.

Table 30—Determinants of off-farm income: regression model

Variable	Parameter	t-Value	Mean of Variable
RFMLAB	-362.947	-1.71	0.231
HHEDUC	184.600	5.68	3.003
RWOMLAB	-689.430	-2.04	0.463
DCID5	411.807	2.00	0.092
DCID4	100.564	0.48	0.089
DCID3	-327.380	-2.04	0.186
DCID2	-480.957	-2.43	0.102
DCID1	-288.961	-1.44	0.097
(Constant)	683.016	3.58	...

$R^2 = 0.12$, $F = 6.50$, degrees of freedom = 3.62.

Notes: Dependent variable: total nonfarm income per capita per year (quetzals).

RFMLAB = farm size per person of working age available for farm work (in hectares per person),
 HHEDUC = household education (years of school),
 RWOMLAB = share of female labor in total household labor, and
 DCID1 ... 5 = village dummy variables.

The model only implicitly addresses the complex issue of the value of human time and its effect on substitution between off-farm versus on-farm work. People may derive utility from spending less time searching and traveling for off-farm work. Also, the search cost for off-farm employment reduces the net income from such sources. An indication for this is that nonmembers of the cooperative spend relatively and absolutely more on transportation. One quetzal of gross income from off-farm work may therefore be worth less to the household than one quetzal of discounted present value earned on the own farm.

Most important and significant is the influence of education levels on off-farm earnings (HHEDUC). Thirty percent of the explained variance is a result of this variable. In the simple model specification, the parameter estimate suggests that one additional year of schooling of the household head raises off-farm income, all else being equal, by 25 percent. It should be recalled that higher levels of human capital were also found to raise labor productivity in agriculture once the production system becomes more complex with new technologies and the new cash crops (see Table 27). Investment in human capital is thus shown here to shift both the agricultural and the nonagricultural income-earning capacities.

Although more available labor per unit of land increases a household's per capita off-farm earnings, an increased share of female labor (RWOMLAB) decreases it. Off-farm income-earning opportunities are less favorable for women in the area, and women's wages tend to be lower than men's in agricultural work by 20 to 30 percent.

The village dummy variables test for the difference with Santiago, which is the largest community and provides the most opportunities. As expected, most of the village dummy variables for the other communities are significantly negative.

The result of this analysis suggests that the net increase in farm income from the new export crops is not identical with the net increase in total income. The increase in total income is diminished by reduced off-farm income, since households withdraw partly from off-farm income earning once they adopt the new export vegetables, for which they allocate more of their time to on-farm work.

EFFECTS OF THE NEW EXPORT CROPS ON EXPENDITURES, CONSUMPTION, AND NUTRITION

Surveys on income—especially direct approaches to income assessment rather than indirect ones via disaggregated accounting of costs and returns, as in this study for agricultural income—suffer from both inaccuracy and high intertemporal fluctuations that do not represent the long-term standard of living of households. This is particularly true in the Western Highlands, where high shares of off-farm income may have significant fluctuations over time. Expenditures on food and nonfood, including the value of home-produced food, represent a more stable indicator of households' permanent income standard.

The following analysis of expenditures has two main purposes: first, to evaluate the effects of the new export crop production on levels of expenditures (using total expenditures as an income proxy); and second, to assess the effects of changes in income levels and the nature of the income stream on the composition of expenditures. Of special interest are questions such as, What happens to the composition of the diet once households earn more income from the export crop? or, Do poor households increase their spending on "luxury items" when they earn more cash income from cash crops than in-kind income from increased subsistence food production?

This analysis is based on the complete expenditure surveys on all food and nonfood items for September 1983 and September 1985. Only the 1985 survey includes foods consumed from own production and an annual expenditure survey on durables and less-frequent expenditures, such as for housing, education, health, feasts, and clothes. The following comparative evaluation between 1983 and 1985 is based on the strictly comparable monthly cash expenditure surveys. Analysis based only on the 1985 survey draws on the full expenditure survey, including own-produced food consumed in the household and items from the annual expenditure survey. This approach was taken to use a maximum of information from the longitudinal comparisons, while presenting the complete picture from the more detailed 1985 survey.¹⁹

Income Effects in Relation to Farm Size and Income Distribution

As shown in the table below, the 1985 cross-sectional comparison suggests that export crop production increases relative income the most in the smallest farm-size classes and thus contributes to a more equal income distribution among the poor. Farm households with more than 1 hectare and who depend more on hired labor for additional labor input actually capture comparatively less benefit from new export vegetable production.

¹⁹ This explains the difference between the 1985 figures in the comparative tables and the 1983 data below versus the 1985 figures in the other tables.

Farm Size	Difference in per Capita Expenditure of Members Versus Nonmembers
Less than 0.25	+ 59.8
0.25-0.50	+ 33.1
0.50-1.00	+ 20.2
1.00 or more	+ 3.4

During the two-year period between the surveys, the distribution pattern of expenditures changed only slightly. This does not mean, however, that the situation of households in poverty in the area is a static one. To what extent did the same households remain static or move upward or downward in terms of real per capita income and what is the role of new export vegetables in this respect? The per capita expenditures from 1983 are, for the purpose of this comparison, expressed in 1985 prices.²⁰

Household transitions from one expenditure class to another inside and outside the export crop scheme provide interesting results (Figure 6). For cooperative members among the poorest tercile in terms of per capita expenditures, only 38.0 percent remained in this position from 1983 to 1985, compared with 55.0 percent for nonmembers. A much higher percentage of members moved upward in the expenditure classes and a much lower percentage moved downward. This holds true for the middle and high income terciles. For instance, among members, 30.4 percent dropped from the middle tercile to the lower and 37.5 percent moved to the higher tercile, among the nonmembers in the middle tercile in 1983, 36.7 percent dropped to the lower and 25.0 percent moved to the higher tercile. The whole spectrum of households moved relatively more upward among members than among nonmembers.

Effects on Expenditure Patterns

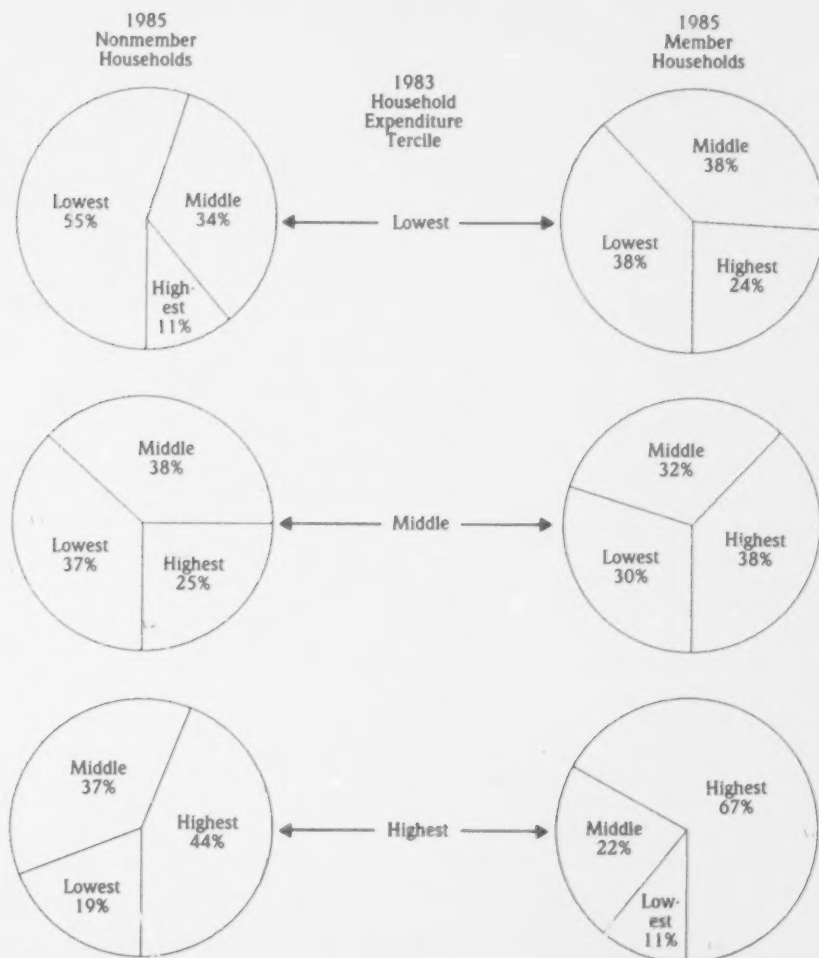
The total expenditures of cooperative members are 20 percent higher than those of nonmembers. The cash expenditures of members on both food and nonfood items and the value of their own-produced food for home consumption are higher. Members' nonfood expenditures are 32 percent higher and the imputed value of the own-produced food for home consumption is 8 percent higher. Even after controlling for farm size, food purchases of members are higher than those of nonmembers. For example, member households with farms of 0.5-1.0 hectare spend 15 percent more per capita on purchased food than nonmembers in the same farm-size group.

Although the absolute food expenditures of cooperative members are greater than those of nonmembers, the share of the budget that members devote to food items is lower. Members spend on average 64 percent of total expenditures on food compared with 67 percent among nonmembers (Table 31).

A more detailed breakdown of household expenditure patterns reveals that relative differences between export crop producers and other farm households are not substantial (Tables 32 and 33). For food items other than meat, eggs, and fish, cooperative members spend relatively less than nonmembers. This implies that income elasticities

²⁰ The reported general inflation rate in Guatemala was 4 percent in 1984, 19 percent in 1985, and 23 percent in 1986. The inflation rate measured in the noncooperative households, which are the majority of households at the location, was used to derive the location-specific inflation rate (33.6 percent over the two-year period).

Figure 6—Transition of cooperative member and nonmember households between expenditure terciles from 1983 to 1985



Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Expenditures are in constant 1985 prices.

for meat, eggs, and fish are above unity and for other food items are below unity. For some of the main staple foods—for example, maize and beans—members also spend absolutely less. It should be noted that this may partly reflect price differences rather than quantity differences. This issue is further addressed later in the food consumption analysis. Also, in 1983, the simple comparison of expenditure patterns of the two groups does not reveal striking differences (Table 34). The direction and magnitude of the differences between item-specific budget shares of members and nonmembers are as expected.

Table 31—Expenditures on foods (purchased and own-produced) and nonfoods, by farm size and duration of cooperative membership, 1985

Group	Food, Purchased		Food, Own-Produced		Nonfood		Total Expenditures	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
By farm size (hectares)								
Members								
Less than 0.25	267.76 ^a	55.5	36.30 ^a	7.5	178.92 ^a	37.0	482.97 ^a	100.0
0.25–0.50	239.86	59.7	37.71	9.4	124.12	30.9	401.69	100.0
0.50–1.00	240.30	49.8	57.08	11.9	184.85	38.3	482.24	100.0
1.00 or more	221.36	48.1	53.07	11.5	185.84	40.4	460.27	100.0
Total average	233.77	52.7	50.06	11.3	159.59	36.0	443.42	100.0
Nonmembers								
Less than 0.25	185.64	61.4	22.77	7.5	93.87	31.1	302.27	100.0
0.25–0.50	182.08	60.2	31.90	10.5	88.53	29.3	302.51	100.0
0.50–1.00	208.83	52.0	52.92	13.2	139.64	34.8	401.39	100.0
1.00 or more	212.89	47.8	55.05	12.3	177.92	39.9	445.87	100.0
Total average	204.82	57.0	35.05	9.8	119.45	33.2	359.32	100.0
By years of membership								
Less than 2 years	237.97	51.4	44.07	9.5	181.36	39.1	463.41	100.0
2–4 years	222.17	53.4	54.30	13.0	140.02	33.6	416.49	100.0
5–6 years	244.99	50.4	52.11	10.7	188.94	38.9	486.05	100.0
Total average	233.77	52.7	50.06	11.3	159.56	36.0	443.42	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Parts may not add to totals because of rounding.

^a There are only 6 observations in this group; in all other groups, at least 25 observations are the basis of the mean values listed.

Between 1983 and 1985, total expenditures at 1985 constant prices for all purchased items (excluding own-produced food) increased by nearly the same rate in member and nonmember households (5.1 and 5.0 percent, respectively). (See Tables 35 and 36.) However, cooperative members spend substantially more on housing and land purchases, which cannot be included in this comparison, as the 1983 baseline does not exist. The annual recall for 1985 showed 84 percent higher spending for land purchases by member households, which may be indicative of a higher savings rate in those households. This expenditure-savings pattern may also be a reason for the higher increase in expenditures among the recent export crop producers versus households that have been in the scheme longer. The introduction of new export vegetables leads to increased consumption of food and nonfood expenditures, especially in the first years of membership. Total expenditures of new members who entered the scheme between the two surveys increased by 33.1 percent and food expenditures went up by 13.8 percent. For members in the scheme longer, consumption expenditures either increased less substantially, or in the case of medium-term members (3–4 years), even dropped in real terms. This pattern is a function of the one-time reallocation of resources to export vegetables and higher returns to land and labor. Once this specialization effect is achieved, further growth is constrained by resource endowments and lack of new technology.

It is noteworthy that landless households' total expenditures dropped in real terms by 1.3 percent (Table 36). Contraction in overall employment in Guatemala and reduced real wage rates during the economic crisis in the mid-1980s greatly affected this group. The favorable employment effects from export vegetables in the cooperative area have

Table 32—Food (including own-produced) and nonfood expenditures of cooperative members, 1985

Commodities, Other Items	Value of Purchases per Capita per Year		Value of Consumed Own Produce per Capita per Year		Total per Capita per Year	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
Maize	15.59	4.0	26.93	53.8	42.52	9.6
Other cereals, bread	39.76	10.1	...	...	39.76	9.0
Pulses	15.72	4.0	6.80	13.6	22.52	5.1
Sugar	14.67	3.7	...	...	14.67	3.3
Roots, tubers, bananas	10.73	2.7	1.11	2.2	11.85	2.7
Vegetables, fruits	27.45	7.0	9.86	19.7	37.31	8.4
Milk products	9.01	2.3	2.33	4.7	11.33	2.6
Meat, eggs, fish	73.23	18.6	2.91	5.8	76.13	17.2
Fat, oil	6.26	1.6	0.12	0.2	6.38	1.4
Other foods	3.34	0.8	...	...	3.34	0.8
Nonnutritious foods, beverages	18.01	4.6	...	...	18.01	4.1
Total food	233.77	59.4	50.06	100.0	283.83	64.0
Fuel, energy	26.30	6.7	...	...	26.30	5.9
Clothing	22.76	5.8	...	...	22.76	5.1
Home articles	11.62	2.9	...	...	11.62	2.6
Hygiene, cosmetics	24.18	6.2	...	...	24.18	5.5
Education	0.55	0.1	...	...	0.55	0.1
Health	13.19	3.4	...	...	13.19	3.0
Transportation	20.27	5.2	...	...	20.27	4.6
Entertainment	3.15	0.8	...	...	3.15	0.7
Loans, transfers, donations	11.16	2.8	...	...	11.16	2.5
Other services	26.42	6.7	...	...	26.42	6.0
Total nonfood	159.59	40.6	...	...	159.59	36.0
Total expenditures	393.36	100.0	50.06	100.0	443.42	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Data are based on one-month recall, September 1985. Parts may not add to totals because of rounding.

apparently not counterbalanced these effects for the landless in the sample but certainly reduced the adverse effects of the economic crisis.

A number of factors determine how scarce resources are allocated by poor households to food consumption versus other consumer goods. To test the extent to which the source of income along with other factors impinges on the budget share allocated to food, a model is specified for estimation of Engel curves that includes relevant sources of income (their relative shares) as explanatory variables together with the level of income. Also, household size is controlled for to account for potential scale effects. Three sources of income are distinguished—income earned from the new export crops, male income earned off-farm, and female income earned off-farm. The hypotheses to be tested are that income earned under men's control (off-farm and from the new export vegetables) is relatively less spent on food than farm income in general, and female-controlled income earned off-farm is relatively more spent on food than general household income. Total expenditure is used as a proxy for expected permanent income in this analysis. It is noted that this is not entirely satisfactory because of the simplistic assumptions regarding savings.

Three different models are specified to evaluate the hypotheses. The first model includes members and nonmembers and tests whether the cooperative has an institutional effect after controlling for the relative income-share effect from the new crops. Institutional arrangements such as cash payment schemes, savings opportunities, and

Table 33—Food (including own-produced) and nonfood expenditures of nonmembers of cooperative, 1985

Commodities, Other Items	Value of Purchases per Capita per Year		Value of Consumed Own Produce per Capita per Year		Total per Capita per Year	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
Maize	22.90	7.1	21.18	60.4	44.08	12.3
Other cereals, bread	31.63	9.7	0.01	0.0	31.65	8.8
Pulses	18.13	5.6	3.72	10.6	21.85	6.1
Sugar	12.16	3.7	...	...	12.16	3.4
Roots, tubers, bananas	9.25	2.9	0.60	1.7	9.85	2.8
Vegetables, fruits	23.43	7.2	7.06	20.2	30.49	8.5
Milk products	8.00	2.5	0.48	1.4	8.48	2.4
Meat, eggs, fish	56.68	17.5	1.95	5.6	58.63	16.3
Fat, oil	5.25	1.6	0.05	0.1	5.30	1.5
Other foods	1.92	0.6	...	...	1.92	0.5
Nonnutritious foods, beverages	15.47	4.8	...	...	15.47	4.3
Total food	204.82	63.2	35.05	100.0	239.87	66.8
Fuel, energy	22.36	6.9	...	...	22.36	6.2
Clothing	15.29	4.7	...	...	15.29	4.3
Home articles	5.01	1.5	...	...	5.01	1.4
Hygiene, cosmetics	22.76	7.0	...	...	22.76	6.3
Education	0.56	0.2	...	...	0.56	0.2
Health	10.45	3.2	...	...	10.45	2.9
Transportation	22.76	7.0	...	...	22.76	6.3
Entertainment	3.77	1.2	...	...	3.77	1.0
Loans, transfers, donations	0.98	0.3	...	...	0.98	0.3
Other services	15.52	4.8	...	...	15.52	4.3
Total nonfood	119.45	36.8	...	...	119.45	33.2
Total expenditures	324.27	100.0	35.05	100.0	359.32	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Data are based on one-month recall, September 1985. Parts may not add to totals because of rounding.

household extension activities may have an effect on the budget share allocated to food. The same model is then estimated separately for members and nonmembers to test for additional differences in spending behavior between the two groups. The results of this analysis are in Table 37.

Food expenditures as a proportion of total expenditures decrease significantly, but not rapidly, with increased income. At total sample mean, a 10 percent increase in total expenditure decreases the budget share to food by only 0.21 percent (computed from Table 37). The dummy variable for separating the cooperative members (MIEM), which is included in the model for the total sample, is not statistically significant. Thus, once income levels and sources are controlled for, membership does not seem to have a distinct effect on shifting the budget share for food. At the margin at higher income levels, however, the budget share to food decreases more rapidly with rising income in member households than in nonmember households (see LTEXPCSQ in the three models, Table 37).

There are indications from anthropological research in the study area that male-controlled income is spent more according to men's preferences than women's and more food may not rank high among men (Nieves 1987, 32). The variables related to income source indicate in this analysis that an increased share of income from new export vegetables (RCASH) decreases the budget share to food beyond the total income effect in cooperative member households. The effect is, however, not highly statistically

Table 34—Food (excluding own-produced) and nonfood expenditures of cooperative members and nonmembers, 1983

Item	Annual per Capita Value of Purchases			
	Members		Nonmembers	
	(quetzals)	(percent)	(quetzals)	(percent)
Maize	13.71	4.9	14.76	6.4
Other cereals, bread	40.68	14.5	38.32	16.6
Pulses	10.11	3.9	7.95	3.4
Sugar	12.61	4.5	11.19	4.8
Roots, tubers, bananas	8.36	3.0	7.16	3.1
Vegetables, fruits	14.56	5.2	10.92	4.7
Milk products	6.05	2.2	5.76	2.5
Meat, eggs, fish	43.55	15.5	37.85	16.4
Fat, oil	4.35	1.6	3.71	1.6
Other foods	3.15	1.1	2.90	1.3
Nonnutritious foods, beverages	14.33	5.1	11.31	4.9
Total food	171.46	61.2	151.85	65.7
Fuel, energy	15.32	5.5	12.65	5.5
Clothing	33.09	11.8	13.37	5.8
Home articles	6.74	2.4	3.94	1.7
Hygiene, cosmetics	12.69	4.5	11.76	5.1
Education	0.42	0.1	0.00	0.0
Health	7.44	2.7	6.91	3.0
Transportation	7.79	2.8	14.24	6.1
Entertainment	1.08	0.4	1.24	0.5
Loans, transfers, donations	4.23	1.5	0.00	0.0
Other services	19.81	7.1	15.13	6.5
Total nonfood	108.61	38.8	79.24	34.3
Total expenditures	280.07	100.0	231.09	100.0

Source: Institute of Nutrition of Central America and Panama survey, 1983.

Notes: Data are based on one-month recall, September 1983. Parts may not add to totals because of rounding.

significant. If, for instance, the income share from new cash crops increases from 0 to 50 percent, the food budget share is reduced by 1.2 percentage points, holding income constant.

This analysis also shows that the net effect for the food budget share of an increased income share of new export crops is very similar to the net effect of an increased share of male nonagricultural income (see the parameters for RCASH in the cooperative member model and for RMNAGINC in the nonmember model in Table 37). On the other hand, women's share in total off-farm income (RFNAGINC) does not appear to have an effect on the budget share to food beyond total income.

Of Q100 of incremental income, cooperative members in the lowest income quartile spend Q52.7 on food, but nonmembers spend Q61.0 on food (Table 38). The estimates of the marginal food expenditures within expenditure quartiles by members and nonmembers show generally lower values for the members within the same expenditure groups. These estimates also point to an interesting relationship between income (total expenditure) and marginal food expenditures. In the poorest quartiles, both members and nonmembers spend less of incremental income on food than the second quartile (in the case of members, even less than the third quartile). Apparently, the poorest households have a high propensity to spend on goods and services other than food at the margin. This expenditure pattern may originate from fixed expenditure obligations for nonfood necessities. As shown in Chapter 7, this expenditure behavior may still be consistent with a high income elasticity of calorie consumption among the poor.

Table 35—Food and nonfood per capita expenditures of cooperative members and nonmembers, 1983 and 1985

Group	Expenditures per Capita					
	Food		Nonfood		Total	
	(quetzals)	(percent)	(quetzals)	(percent)	(quetzals)	(percent)
1983						
Landless	257.30	54.8	212.00	45.2	469.30	100.0
Members by years of membership ^a						
2 or less	209.87	66.3	106.84	33.7	316.71	100.0
3-4	225.08	60.7	145.94	39.3	371.02	100.0
5-6	248.16	58.7	174.33	41.3	422.49	100.0
Total average for members	229.07	61.2	145.10	38.8	374.17	100.0
Total average for nonmembers	202.87	65.7	105.86	34.3	308.73	100.0
1985						
Landless	270.83	58.5	192.15	41.5	462.93	100.0
Members by years of membership ^a						
2 or less	238.76	56.6	182.86	43.4	421.63	100.0
3-4	222.17	66.1	113.77	33.9	335.94	100.0
5-6	246.29	57.1	184.96	42.9	431.25	100.0
Total average for members	233.77	59.4	159.59	40.6	393.36	100.0
Total average for nonmembers	204.82	63.2	119.45	36.8	324.27	100.0

Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Data exclude own-produced food consumed in the household, as the 1983 survey does not include related information. All data are in 1985 prices. Parts may not add to totals because of rounding.

^a Years of membership in the cooperative as of 1985.

Table 36—Change in per capita expenditures, by cooperative membership and duration of membership, 1983-85

Category	Cooperative Members		Nonmembers	
	Change in Total Expenditures	Change in Food Expenditures	Change in Total Expenditures	Change in Food Expenditures
	(percent)			
Landless	...	...	-1.3	+ 5.3
Cooperative members by years of membership				
2 or less ^a	+ 33.1	+ 13.8	...	...
3-4	-9.5	-1.3	...	...
5-6	+ 2.1	-0.8	...	...
Total average	+ 5.1	+ 2.1	+ 5.0	+ 1.0

Sources: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: Value of own-produced food is not included here, as the 1983 survey did not include these items. In 1985 the value of own-produced food was 13 percent of total household expenditures for cooperative members and 11 percent for nonmembers.

^a This group became members in the cooperative two years or less before 1985; thus they entered the cooperative after the 1983 survey.

Table 37—Determinants of budget share to food in cooperative member and nonmember households, 1985: regression model

Variable	Total Sample		Nonmembers		Members	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
HHSZ	0.003765	1.424	0.005195	1.462	0.002795	0.704
RCASH	-0.023010	-1.691	-0.018140	-1.047	-0.038070	-1.655
RFNAGINC	0.009191	0.261	0.018070	-0.411	-0.007464	-0.104
RMNAGINC	-0.023100	-1.706	-0.033500	-2.263	0.020290	0.578
MIEM	0.010550	0.797				
LTEXPC	0.279710	1.861	0.156420	0.913	0.579280	1.821
LTEXPCSQ	-0.035270	-2.809	-0.024610	-1.694	-0.060220	-2.314
(Constant)	0.248630	0.557	0.596770	1.193	-0.630700	-0.650
	R ² = 0.34		R ² = 0.37		R ² = 0.33	
	DF = 342		DF = 178		DF = 158	
	F = 25.6		F = 17.7		F = 12.8	

Notes: Dependent variable: budget share to food.

- HHSZ = household size (number of persons);
- RCASH = ratio of income from new export vegetables over total income (total expenditure is used as proxy for expected total income);
- RFNAGINC, RMNAGINC = ratio of female (male) nonagricultural off-farm income over total income (total expenditure is used as proxy for expected total income);
- MIEM = membership in cooperative (1 = members, else = 0);
- LTEXPC = log of per capita total expenditures serving as a proxy for expected (permanent) income; and
- LTEXPCSQ = LTEXPC squared.

Effects on Calorie Consumption

The problem of protein-energy deficiency of the rural poor in Guatemala is well researched (see, for example, Balderston et al. 1981; Mata 1978). It is, therefore, not the objective of this research to comprehensively evaluate the nature and prevalence of food deficiencies and malnutrition but to assess the direction and magnitude of changes in consumption and nutrition due to increased export crop production in smallholder households.

Differences in food availability in the Western Highlands households are closely related to income. This is to be expected at such low levels of income. If the sample is grouped into four equal groups by total expenditure per capita (including the value of home-produced food consumed), the lowest quartile had less than two-thirds of calories per adult equivalent unit as the highest quartile (Table 39). Within the Western Highlands, the degree of poverty as reflected in levels of food availability in households indicates a considerable degree of inequality among the poor. It should be noted that calorie availability for this assessment is based on monthly purchases of food and food from own production used for home consumption. This rough approach to food consumption is likely to result in higher calorie per capita figures than an accounting of actual food intake, since losses in storage and processing and losses due to waste are not included. Ideally, actual food intake of individual family members would be preferred in view of findings from earlier research in Guatemala that suggest the income-food intake relationship (calories) is more pronounced among children (preschoolers) than

Table 38—Incremental expenditure on food by cooperative member and nonmember households, by expenditure quartile, 1985

Expenditure Quartile	Share of Incremental Expenditure on Food	
	Members	Nonmembers
	(percent)	
Lowest	52.7	61.0
Second	70.4	76.6
Third	58.1	57.0
Highest	31.9	44.5

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Notes: The estimates of the presented marginal shares of food expenditures are based upon the following regression model estimated separately for each of the groups and quartiles: food expenditure per capita = $f(\text{HHSZ}, \text{LTEXPC}, \text{RCASH}, \text{RFNAGINC}, \text{RMNAGINC})$,

where

- HHSZ = household size (number of persons);
- LTEXPC = log of per capita total expenditures serving as a proxy for expected (permanent) income;
- RCASH = ratio of income from new export vegetables over total income (total expenditure is used as proxy for expected total income); and
- RFNAGINC, RMNAGINC = ratio of female (male) nonagricultural off-farm income over total income (total expenditure is used as proxy for expected total income).

Table 39—Food availability and composition of food consumption by expenditure quartiles (mean values) in the sample, 1985

Category	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
	(per capita)			
Average of 1985 expenditures (quetzals) ^a	186	283	410	771
Calorie availability per adult equivalent per day				
Cooperative members	2,214	2,563	3,088	3,446
Nonmembers	2,122	2,680	3,101	3,401
Total average	2,153	2,628	3,094	3,429
Percent of total calories ^b				
Maize	57.2	57.0	54.6	49.4
Other cereals	6.1	7.4	5.7	6.8
Pulses	9.0	8.3	8.2	7.3
Sugar	13.7 ^a	11.7	10.7	11.8
Meat, eggs, fish	4.8	5.6	6.5	7.4
All other foods and beverages	9.2	10.0	14.3	17.3
Total (percent)	100.0	100.0	100.0	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Includes the value of own-produced food consumed by the household.

^b Average of total sample.

for the household as a whole (Flores 1975, 10). To the extent that Flores's finding based on survey data from the 1960s is still valid, the household income-calorie consumption relationship for preschoolers is assumed to be even higher than the total household averages presented here.

More than half of the available calories in households are from maize, but this share decreases with increasing income (Table 39). Also, the calorie share of pulses (mainly beans) decreases, while the share of meat, eggs, fish, and other food calories increases with higher income. Accordingly, the price per calorie increases with rising income as the diet becomes more diversified. Cooperative members spend an average Q0.265 per 1,000 calories, while nonmembers spend Q0.240 per 1,000 calories, or 10 percent less.

Comparison of food availability between export vegetable-producing households (cooperative members) and other households shows that the latter acquire, on average, about 7 percent fewer calories per capita. Members acquire a lower share of maize calories, but the absolute amount of calories per capita from maize is still 4.4 percent higher than in nonmember households (Table 40).

The diet composition of cooperative members and nonmembers is not significantly different. Members have a slightly larger share of calories from sugar, starchy roots, vegetables, meat products, fats, and other processed foods (Table 40). These differences between averages of members' and nonmembers' consumption appear to be largely determined by the differences in income levels and distribution. As shown in Table 39, per capita calorie consumption of members within the same expenditure quartile as nonmembers is sometimes slightly higher (for example, in the lowest and highest quartiles) and sometimes slightly lower (for example, in the two middle quartiles). More refined approaches are used below to test for the significance of these differences.

The basis for the concept of this analysis of the effects of increased export crop production on food consumption is that the principal relationships between change in prices and levels of income and food consumption are well established. Since real income increased in households that adopted new export crops, the hypothesis is that food consumption levels increased, too. Less clear are hypotheses related to the effects

Table 40—Food availability and composition of food consumption in cooperative member and nonmember households, 1985

Category	Members	Nonmembers
Calorie availability per adult equivalent per day	2,931	2,733
Percentage of total calories		
Maize	53.8	55.3
Other cereals	6.2	6.8
Pulses	8.1	8.3
Sugar	12.1	11.8
Starchy roots, bananas	2.7	2.5
Vegetables, fruits	5.6	5.4
Milk	0.5	0.4
Meat, eggs, fish	6.4	5.8
Fats and oils	1.3	1.0
Other foods and beverages, meals outside home	3.3	2.7
Total (percent)	100.0	100.0

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

of income-source changes, control over household income, and the form and frequency of income. (For a review of evidence on this issue, see Braun and Kennedy 1986, 55-59.) Export vegetable production impinges on all of these jointly with its favorable effect on the overall real income. The net effect of export vegetable production on household food consumption may thus be smaller or larger than the "pure" income effect suggests. These factors will be evaluated in the following model, which attempts to explain aggregate household-level food availability in the form of calories (c_i):

$$c_i = f(I_i, I_i^2, S_j, D_n, P_m, M_q), \quad (9)$$

where

I_i = per capita income of household i (total expenditure is used as income proxy),

S_j = a set of j variables describing sources of income (from new cash crops, off-farm women's income),

D_n = a set of n variables describing household size and composition,

P_m = a set of m variables depicting food prices that respective households face, and

M_q = a set of q variables describing the membership and its duration in the cooperative for export vegetable production.

The model is estimated both for the total sample and separately for the lowest 50 percent of income groups among members and nonmembers. The actual specifications of the model along the above-formulated hypothesis and the estimation results are presented in Table 41.

The estimated response of calorie availability to changes in levels of income is highly significant. Additional income increases calorie consumption (LTEXPC), but at decreasing rates at the margin (LTEXPCSQ). The elasticity of calorie consumption with respect to income is 0.306 at the total sample mean. Since the new export crops increased household per capita income, a positive effect for calorie consumption in cooperative member households is to be expected according to these parameter estimates.

Since the food expenditure analysis in the previous section suggested that export crop income is spent less than other income for food at the margin, the extent to which this translates into calorie consumption is tested. It is hypothesized that membership in the cooperative reduced women's off-farm income and increased shares of cash income from new crops, which are controlled by men (see, for example, Tinker 1979).

Most purchased food items in Guatemalan households are actually acquired by women. Maize is the only food that is purchased in a significant amount by men (Table 42). In this environment, women's income levels may have a particularly positive effect on levels of food acquisition over and above total income of the household. This hypothesis, tested by the variable RFNAGINC—share of (off-farm) income earned by women in total income—in Table 41, does not find statistical support. Income earned by women off-farm does not significantly change calorie acquisition after controlling for total income, although it was found earlier in the expenditure analysis that an increased share of female-controlled off-farm income increased the budget share to food beyond the income effect. The explanation for this difference may be that the

Table 41—Availability of calories in households and export vegetable production: regression model

Variable	Total Sample		Lowest Two Quartiles			
	Parameter	t-Value	Cooperative Members		Nonmembers	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
LTEXPC	20,446.410	2.663	3,928.210	1.218	6,289.810	3.794
LTEXPCSQ	-1,328.330	-2.072				
RFNAGINC	-1,685.120	-0.971	-1,096.170	-0.437	-1,675.740	-0.606
RCASH	57.254	0.082	553.030	0.438	173.124	0.194
HHSZ	1,747.343	13.021	1,244.150	5.075	1,510.410	6.629
RCHILD	-6,627.550	-3.106	-4,957.520	-1.088	-4,923.010	-1.230
MPRICE	-82,424.880	-5.774	-46,732.990	-1.821	-54,545.190	-1.648
BPRICE	505.477	1.020	949.183	0.826	1,139.320	1.168
MIEM	-829.710	-1.218				
(Constant)	-47,623.400	-2.060	-6,841.310	-0.394	-18,424.900	-1.417
	R ² = 0.41		R ² = 0.33		R ² = 0.64	
	F = 26.6		F = 4.20		F = 9.60	
	DF = 340		DF = 60		DF = 98	

Notes: Dependent variable: calories available for consumption per day in the household (from purchases and consumed from own production, 1985).

- LTEXPC = log of total expenditures per capita per year in quetzals (as a proxy for permanent income);
- LTEXPCSQ = LTEXPC squared;
- RFNAGINC = ratio of female off-farm income over total income (total expenditure is used as proxy for permanent income in the ratio);
- RCASH = ratio of income from new cash crops over total income (total expenditure is used as proxy for permanent income in the ratio);
- HHSZ = number of persons in the household;
- RCHILD = ratio of number of children under 5 over number of persons in the household;
- MPRICE, BPRICE = price of maize, beef; and
- MIEM = membership in the cooperative (1, else = 0).

Table 42—Purchasers of food items in household transactions

Food Item	Husband	Wife	Other Person
		(percent)	
Milk	8	87	5
Eggs	1	92	7
Pork	2	95	3
Sausage	2	90	8
Maize	24	76	...
Beans	2	93	5

Source: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Data are based on one-month recall.

usual off-farm work in trading and services takes women away from home from morning till sunset even if temporary migration is not involved, and that more expensive time-saving foods may enter the budget of such households. Obviously, generalizations of the relationships between women's income and food acquisition are risky if the interactions with mode of income earning are not taken into account. The issue of the actual value of human time discussed above and the possibly different utility derived by households from on-farm versus off-farm work at equal returns per unit of time is also relevant here.

An increased share of income from new export crops (RCASH) does not have a significant effect on calorie acquisition beyond the income-level effect. The respective parameters of this variable are not statistically significant in any of the three models (Table 41). That is, income from the new export vegetables translates into calorie availability no differently than income in general.

The model for the total sample tests whether membership in the cooperative (MIEM) and the share of income from export crops (RCASH) affect calorie acquisition beyond the absolute income effect. The respective parameter estimate of cooperative membership suggests a marginally significant negative effect on calorie availability (the parameter of MIEM is not statistically significant; see column 1, Table 41). Although this appears as the general picture, the situation seems different at low-income levels, as shown by the separate estimates of the calorie consumption functions for members and nonmembers in the lowest income half of the joint income distribution (Table 41). Nonmembers show a significant positive response in calorie acquisition with rising income but members do not. Calculated at the identical income level at the mean of the joint sample—not at the differing means of the two separate samples, which would distort the picture—cooperative members increase their calorie acquisition by 2.8 percent with 10 percent more income, but nonmembers increase theirs by 4.4 percent. (This income elasticity of calorie acquisition among members is based on a parameter estimate that is statistically not significant—see Table 41.) The households in the area are clearly price-responsive in their calorie acquisition. Understandably, the maize price (MPRICE) is most prominent in this respect, as about 50 percent of calories come from maize.²¹ The estimated (maize) price elasticity of calorie consumption is high; -1.15 among the lowest income half of nonmembers and 0.95 among the members in that income group, which means that a 10 percent increase in the maize price reduces calorie availability by 9.5 percent at the household level. If increased export vegetable production were to shift farm households from net sellers or self-sufficiency to net purchasers, or shift whole village communities in the Western Highlands to net importers, the related price effect could have a significant effect on calorie consumption.

In the final assessment, the effects of increased export crop production on food acquisition are on average positive in terms of calorie availability to the households, supporting further the conclusion drawn from the agricultural production and income assessments that household-level food security seems to have improved. Yet the change in the source of income-earning reduces the positive gross-income effect for calorie acquisition from an expected increase of 7.2 percent to an overall net effect of 1.9 percent in a typical farm household that joined the cooperative (based on model in column 1, Table 41). The following section traces these effects to the nutritional status of children.

²¹ Price variability in the cross-sectional sample results from local price differences and the fact that households face in varying degrees a c.i.f. price if they are purchasing or an f.o.b. price if they are selling. To households that are only consuming their own-produced maize, the local f.o.b. price was assigned to represent the shadow price of maize consumption.

Effects on Nutrition

The nutrition problem in the Western Highlands is a syndrome that stems from poverty. The health and sanitation environment along with the ability to acquire food—be it from own production or market—and employment, especially of mothers, are important interrelated factors that determine the nutritional performance of children (Balderston et al. 1981). The new export vegetable production scheme directly or indirectly impinges on all of these variables.

Patterns of Malnutrition in the Region and Sample Population

In a number of social indicators, cooperative member households appear to have a better standard of living than nonmembers. Many of these indicators may be directly or indirectly linked to increased income of members, but other indicators may reflect their desire and ability to change their living standards as compared with others in the communities. In general, members have higher education levels, better housing and water supply conditions, and higher-quality health services (clinics). Basic health services, such as vaccination, are used similarly by the two groups. Although they are generally less poor, the percentage of members obtaining food aid tends to be higher than among nonmembers (see indicators, Table 43).

As found in the above analyses, both real household income and food from own production increased due to export vegetables. Women's on-farm employment increased, leading to less off-farm work. Employment in the six communities also increased due to export cropping; this should be beneficial to the local landless and smallest farmers, who depend more on off-farm work. However, the country went through a period of general economic decline in the mid-1980s that adversely affected economic opportunities of the poor. Thus it is an open question whether the nutritional situation in the six communities generally improved. This question will be evaluated using nutritional status indicators of children—weight-for-age, height-for-age, and weight-for-

Table 43—Selected social indicators for cooperative members and nonmembers

Indicator	Members	Nonmembers
	(average)	
Household size (persons)	6.7	6.4
Literate heads of household (percent)	61.7	55.4
Electricity in the house (percent)	60.3	47.7
Housing conditions		
Houses with mud floor (percent)	41.7	56.5
Houses with corrugated iron (percent)	69.7	49.8
Own water tap or own well (percent)	79.6	61.9
Use of health services (percent)		
At clinics	45.6	33.4
At pharmacy or other services	50.1	60.6
Vaccination of children under 5 years (percent)		
Measles	68.6	65.1
BCG	70.8	67.1
DPT (3 or 4 doses)	50.0	46.6
Polio (3 or 4 doses)	48.8	45.3
Food aid received in		
1983 (percent of households)	53.2	45.8
1985 (percent of households)	45.0	42.8

Source: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

height. In this analysis, the respective indicators are normalized for age differences by expressing them in terms of their deviation from the age-specific standards over the standard deviation (Z-scores).²²

The general nutritional situation in the study area, as represented by children in households not participating in the cooperative, is not very different from other parts of the highlands despite the accessibility of the survey villages to Guatemala City and to infrastructure (Table 44). Also, prevalence rates of malnutrition in these communities (especially height-for-age) are at similar levels to, or even higher than, the rates found in more remote parts of the Western Highlands (Table 45).

Comparing the Guatemalan data with comparable data from Africa, significant differences are found. For instance, average Z-scores for growth retardation of about -1.4 were found in a comparable survey in The Gambia (von Braun, Puetz, and Webb 1989). However, a straight comparison of average Z-scores of anthropometric indicators across populations may not be fully justified because of ethnic differences between populations. Therefore, the focus is mainly on relative changes rather than absolute levels of anthropometric status as a nutritional indicator in this analysis.

A comparison of the 1983 and 1985 prevalence rates does not indicate a general improvement in nutritional status (Table 45). However, this tendency should not be generalized to local developments. During these years, Guatemala was going through a severe economic crisis, which may be the reason for this general pattern of development. Desired information on change over time in anthropometric indicators from other Guatemalan locations in the early 1980s is not available. Comparison of cooperative members with nonmembers shows that children of members tend to be better off in terms of weight-for-age and height-for-age and about the same in terms of weight-for-height.

Table 46 presents an analysis of the prevalence of wasting and stunting among the children of families who are members versus nonmembers. Two cutoff points are used for both the weight-for-height and height-for-age standards. The commonly used cutoff point to classify wasting is children below 80 percent weight-for-height, and for stunting, below 90 percent height-for-age standards. Only children 6-60 months of age are included. By the above standards, 66.7 percent of children of members and 75.7

Table 44—Nutritional status of children under 60 months in the study area and other locations in Guatemala

Area	Weight-for-Age	Height-for-Age	Weight-for-Height
		(average Z-scores)	
Study area, 1985 ^a	-1.89	-3.27	0.11
A study area in four villages in Patulul area, 1984	-1.98	-3.26	0.00
A study area of coffee plantations, 1984	-1.65	-2.61	-0.05

Sources: Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985; and data from Victor Valverde, Hernán Delgado, Rafael Flores, and Ricardo Sibrián, "Minimum Wage Law and Nutritional Status in Guatemala," Institute of Nutrition of Central America and Panama, Guatemala City, 1985, (mimeographed).

^a Children aged 6-60 months of the nonmembers of the cooperative.

²² The National Center for Health Statistics standards were used for Z-scores. Z-scores are standard deviation scores. For any value X_i , the Z-score is $(X_i - \bar{X})/S$, where $\bar{X}$ is the median and S is the standard deviation of the reference population. A negative (positive) Z-score means the specific value X_i is "Z" standard deviations below (above) the median of the reference population.

Table 45—Prevalence of malnutrition in the Western Highlands of Guatemala

Area	Children Below -2 Z-Scores		
	Weight-for-Age	Height-for-Age	Weight-for-Height
		(percent)	
Study area, 1983 ^a	43.2	82.1	1.7
Study area, 1985 ^a	42.4	89.2	1.3
Western Highlands (north)	36.8	67.6	1.7
1983 ^b	36.8	67.6	1.7
1987 ^c	58.3	66.2	8.2
1987 ^d	51.7	81.8	4.2

Sources: Based on data from USPADA/INCAP/UCPRODA, *Resultados del Análisis de las Encuestas de Base Agroeconómica, Dieta y Estado de Nutrición Infantil*, Project MAGA-AID 520-T-034/0255, 1983 (Guatemala City: INCAP, 1986); Cooperación Guatemalteca-Alemana Alimentos, *Informe Final, Baseline Survey, Análisis del Grupo Meta (Población Rural de los Departamentos El Quiché-Sur y Totonicapán)*, vol. 2 (Guatemala City: COOGAT, 1987); and Institute of Nutrition of Central America and Panama, *Informe de los Resultados de las Encuestas de Consumo de Alimentos y Estado Nutricional*, Project MAGA-AID 520-T-034/0255, 1987 (Guatemala City: INCAP, 1988).

^a Children aged 6-60 months of the nonmembers of the cooperative.

^b Six departments: Huehuetenango, Quetzaltenango, San Marcos, Totonicapán, El Quiché, and Sololá; children aged 0-60 month(s).

^c Two departments: Totonicapán and El Quiché; children aged 0-71 month(s).

^d Six departments as in note (b); children aged 12-60 months.

percent of children of nonmembers were stunted in 1985. This reflects an increase in both groups, although somewhat higher in the nonmember group. Severe stunting (below 80 percent) hardly prevails among children of members (0.6 percent) but affects children of nonmembers (5.8 percent). Severe wasting, which represents an indicator of short-term nutrition problems, is practically nonexistent in both groups. In 1985, 0.6 percent of children of members and 1.0 percent of children of nonmembers were affected.

Table 46—Prevalence of malnutrition among children of cooperative members and nonmembers, aged 6-60 months, 1983 and 1985

Year	Members ^a		Nonmembers ^a	
	Weight-for-Height	Height-for-Age	Weight-for-Height	Height-for-Age
	(percent of children below 90 percent of reference standard) ^b			
		(stunted)		(stunted)
1983	15.1	59.3	10.2	65.1
1985	6.8	66.7	7.8	75.7
	(percent of children below 80 percent of reference standard) ^b			
	(wasted)		(wasted)	
1983	2.3	0.6	0.9	4.2
1985	0.6	0.6	1.0	5.8

Source: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

^a Number of children: 1983 = 172 members, 215 nonmembers; 1985 = 177 members, 206 nonmembers.

^b The standards used are the National Center for Health Services standards.

In both groups, children who have been moderately underweight substantially improved, relatively more among cooperative members. Between 1983 and 1985, the percentage of children below 90 percent of the weight-for-height standard decreased from 15.1 to 6.8 percent among children of members, and from 10.2 to 7.8 percent among children of nonmembers.

Income and Nutritional Improvement

The straightforward comparisons of mean values and prevalence rates of malnutrition provide limited insights, since the earlier analysis showed that members of the cooperative have higher incomes than nonmembers. The sample is therefore broken into three income classes, using expenditure per capita as an income proxy. For children 6-120 months of age, there is a generally positive but weak relationship between income and nutritional status (Table 47). While children in the middle and highest terciles showed a slight improvement in their weight-for-age Z-scores, children from households in the lowest group appear to have worsened between the two rounds. The prevalence of stunting (height-for-age) increased among children from households in the bottom and middle terciles, while it decreased among the highest income group. The higher prevalence of stunting may be related to the worsening of the general socioeconomic conditions during the first half of the 1980s, when real per capita GDP decreased by 20.5 percent (1981-85) in Guatemala.

Because of increases in real income, available food from own production, and women's on-farm employment, as well as overall employment in the six communities, which is beneficial to the landless and the smallest farmers, it is hypothesized that the nutritional situation improved for both members and nonmembers of the cooperative. The following model is a reduced form of income-nutrition relationships. At higher

Table 47—Income levels and prevalence of malnutrition among children of cooperative members and nonmembers, 1983 and 1985

Measure	Year	Number in Sample	Children Below -2 Z-Scores		
			Lowest Income Tercile	Middle Income Tercile	Highest Income Tercile
(percent of children 6-120 months)					
Weight-for-age	1983	755	41.6	38.9	36.8
	1985	824	43.0	36.5	32.2
Height-for-age	1983	755	77.4	75.0	77.7
	1985	824	83.4	87.4	74.4
Weight-for-height	1983	755	1.9	0.8	2.1
	1985	824	1.9	0.7	0.8
(percent of children 6-60 months)					
Weight-for-age	1983	406	46.2	38.0	39.7
	1985	394	48.3	38.2	34.1
Height-for-age	1983	406	78.7	78.5	83.6
	1985	394	84.8	95.8	81.1
Weight-for-height	1983	406	2.4	1.7	0.9
	1985	394	1.7	1.4	0.8

Source: Institute of Nutrition of Central America and Panama survey, 1983; and Institute of Nutrition of Central America and Panama/International Food Policy Research Institute survey, 1985.

Note: Income levels refer to expenditures of respective year in per capita terms as income proxy (excluding value of own-produced food consumed, which was not collected in 1983 survey).

income levels, reduced marginal effects of increased income for nutritional improvement are expected. It is further hypothesized that an increased share of male nonagricultural income or export crops has a negative effect on child welfare, holding household income constant. If a disproportional share of income is spent on luxuries, children's nutritional status would deteriorate at a given income level. On the other hand, it is hypothesized that an increased share of female-controlled income leads to increased child welfare-related spending and nutritional improvement. Subsistence food income is included in the total household income variable in this reduced-form model, which has the following formula:

$$S_{ij} = f(\text{DEM}_{ij}, \text{INCOME}_j, \text{INCOMP}_j), \quad (10)$$

where

S_{ij} = nutritional status of child (i) in household (j) in 1985;

DEM_{ij} = demographic variables of child (sex, age in months—level and squared—birth order);

INCOME_j = household (j) income per capita per year (and the respective squared term); and

INCOMP_j = composition and sources of income (shares from new export crops, male- or female-earned nonagricultural income).

The results indicate that the level of income is highly significant for the weight-for-age, height-for-age, and weight-for-height indicators (Table 48). At higher levels of

Table 48—Effects of income and income source and composition on nutritional status: multivariate analysis for children aged 6-120 months

Explanatory Variable	Weight-for-Age Z-Scores		Height-for-Age Z-Scores		Weight-for-Height Z-Scores	
	Estimated Parameter	t-Value	Estimated Parameter	t-Value	Estimated Parameter	t-Value
Age in months	-3.489E-03	-0.85	-0.0156	-3.03	-9.485E-03	-2.28
Age squared	3.497E-05	1.14	1.397E-04	3.64	1.053E-04	3.39
Birth order ^a	1.706E-04	0.01	-0.0240	-1.37	0.0220	1.55
Sex (male = 1, female = 2)	7.083E-03	0.12	0.0379	0.52	-0.0562	-0.96
Duration of breastfeeding ^b	9.663E-05	2.03	1.894E-04	3.17	-3.063E-05	-0.63
Income per capita ^c	8.231E-04	3.20	7.807E-04	2.41	5.162E-04	1.98
Income squared ^c	-3.930E-07	-2.74	-3.489E-07	-1.93	-2.625E-07	-1.80
Share of male nonagricultural income	0.1613	2.00	0.3291	3.24	-0.0531	-0.67
Share of female nonagricultural income	0.4953	2.20	0.4895	1.73	0.3140	1.37
Share of income from export crops	0.1569	1.88	0.1958	1.81	0.0640	0.73
Constant	-2.1165	-12.89	-3.110	-15.08	0.0549	0.33
R ²	0.032	...	0.073	...	0.028	...
F-value	3.590	...	7.280	...	3.290	...
Degrees of freedom	785	...	785	...	785	...

^a First-born child = 1, second = 2, and so forth.

^b Variable only for children above 24 months of age (else = 0).

^c Expenditure per capita per year is used as a proxy for income.

income, the marginal effect is reduced as hypothesized, indicated by the negative sign for the squared income term. Thus the effect of marginal income on nutrition is greater in poor households than the sample means indicate. At sample mean, a 10 percent increase in income increases the weight-for-age Z-score by 1.5 percent, the height-for-age Z-score by 0.9 percent, and the weight-for-height Z-score by 9.7 percent. The high income elasticity of short-term nutritional improvement (weight-for-height) suggests that even marginal income growth among the poor leads to significant short-term weight gains of children. It thus can be inferred that increased real income due to the export crops has a particularly significant effect in this respect. To reduce stunting substantially, however, would require a major increase in income.

Higher shares of either male or female off-farm nonagricultural income improve the nutritional status of children. Although this is contrary to the study hypothesis concerning male-controlled income, the respective parameter values indicate different levels of impact. In the weight-for-age model, women's income always had a greater impact on nutritional status than men's income. In the height-for-age model, which depicts long-term effects, the differential effect between male- and female-controlled income is less pronounced; for short-term nutritional status (weight-for-height), income control within the household does not appear to be an issue (the parameters are not statistically significant).

A higher share of income from the new export crops has a low positive effect on nutrition after controlling for income in the weight-for-age and height-for-age models but is not significant in the weight-for-height model. The hypothesis that income from new cash crops, which is largely male-controlled, would be disproportionately used for nonfood and luxury items that would adversely affect nutrition of children in the household does not find support in this analysis.

Social Programs

The commercialization process studied in this case is inseparable from the Cuatro Pinos cooperative scheme. The cooperative has developed and implemented three types of social programs: productive, educational, and medical. These programs may improve the health status of children and have a long-term effect on nutritional improvement beyond the income-consumption effect of the new export crops.

Productive programs include a rabbit project that was started in March 1986 for women. This project consists of providing credit for acquisition of a rabbit pen and three rabbits—credit that must be repaid in one year. Furthermore, participants are trained in rabbit growing, maintenance, and slaughtering techniques. As of April 1987, 105 women had participated in the project. It is estimated that 50 percent of the rabbit meat production is for own consumption, and the remainder is sold to supermarkets in Guatemala City.

By statute, 10 percent of the cooperative's profits are earmarked for its educational fund. The first program (initiated in Santiago in 1978) was an adult education program for members and nonmembers, with primary education and literacy classes. In 1983 the program was expanded to three communities and was taught by three teachers directly employed by the cooperative. In 1986, 132 adults (36 nonmembers) finished the primary education subprogram and 66 (12 nonmembers) finished the literacy subprogram.

In 1980, with funds from the Swiss Group, a nongovernmental development organization, several children began to receive study scholarships. The scholarship program was formally organized in 1985, and scholarships are provided for secondary education and vocational training and normally cover tuition and books. The education committee

of the cooperative reviews and approves scholarship applications. In 1987, 47 scholarship applications were approved.

An institution providing secondary education has been established in Santiago and receives financial assistance from the cooperative, thus benefiting some members indirectly. Additional educational programs for schoolchildren were started in 1985 in production techniques related to vegetables and aspects of cooperativism, and in 1986 cooperative education courses were organized for members, their spouses, schoolchildren, and cooperative officials. Technical training in such fields as administration and accounting was initiated in 1987 for personnel of the cooperative.

In 1984 the cooperative organized a food and nutrition program for spouses of members. As of mid-1987, 225 women have participated in this program, whose contents center on different ways of preparing vegetables (particularly broccoli, snow peas, and cauliflower) and their nutritive values, in order to stimulate more own consumption of these foods. The program is conducted by two home extension workers who are employees of the cooperative and were partially trained by INCAP.

The medical services program consists of several subprograms: maternal-infant, pre- and post-natal care, outpatient consultations, and deworming. The program is currently carried out in all communities from which the cooperative draws members. The staff consists of a full-time doctor (as of August 1986) who is an employee of the cooperative. The doctor spends four afternoons a week in the health clinic in Santiago and divides the remainder of the time among the other communities. This is in addition to a full-time health promoter who, among other things, prescribes medicines. From 1982 to August 1986, a medical doctor provided services two mornings a week in Santiago and Pacul. In January 1987 the cooperative established a pharmacy in Santiago that also supplies medicines to the other communities.

Food Consumption and Health-Based Model of Nutritional Improvement

To assess the effects of increased commercialization on the nutritional status of children, it is hypothesized that the related income effects—identified in the reduced-form model above—can be traced to nutrition through increased food consumption and improved health and sanitary conditions. Such further separation of the elements of the growth and development process traced to nutritional effects is desirable for policy and program design.

The model, unlike the reduced-form, income-based model in the previous section, is a cohort-specific analysis of determinants of change in nutritional status. The model for the identical children aged 6-60 months in 1983 and 30-84 months in 1985 has the following form:

$$dS_{ij}^{(1983-1985)} = f(DEM_{ij}, CAL_{ij}, BRE_{ij}, SAN_{ij}, EDU_{ij}, PER_{ij}, S_{ij}^{(1983)}), \quad (11)$$

where

$$dS_{ij} = S_{ij}^{(1985)} - S_{ij}^{(1983)};$$

$$DEM_{ij} = \text{demographic variables of child (sex, age in months—level and squared—birth order);}$$

- CAL_i = household-level calorie consumption per adult equivalent (level and squared);
 BRE_{ij} = breastfeeding duration (children over 24 months);
 SAN_i = sanitary environment (latrine);
 EDU_i = education of head of household (years of schooling);
 PER_i = years of cooperative membership; and
 S_{ij} = nutritional status of child $_{(ij)}$ in household $_{(i)}$ in 1985 (weight- or height-for-age, or weight-for-height Z-scores).

In this model of the determinants of change in nutritional status, household calorie availability is included as a proxy variable for household food consumption. Household food availability may not be a satisfactory indicator of child food consumption. The hypothesis is that children capture a share of incremental household calories. Additional indicators related specifically to breastfeeding duration are also introduced.

Poor latrine facility is used as a proxy for sanitation environment. It is further hypothesized that households with better education have the ability to make better use of available resources to improve the health and nutrition of their children. Finally, the duration of membership in the cooperative is evaluated for its effect, beyond the income-consumption effect, on children's health and nutritional status. Beneficial effects from cooperative membership may come from participation in the social programs, such as literacy classes, food and nutrition education of women, and improved information exchange among communities. Adverse effects might result from changes in income control not captured fully by the food consumption variables and women's time constraints for child-nurturing activities.

Inclusions of an individual child's nutritional status indicator (1983) before the period during which change is measured (1983-85) take account of individual characteristics. This increases the overall explanatory power of the models as compared with the purely cross-sectional, income-based models. The lower the Z-score at the outset (1983), the greater the reduction in weight deficiencies during the two years of observation.

For instance, children who were underweight at -2 Z-scores in 1983 tended to catch up by one Z-score over the period (-0.5004×-2 , see Table 49). This points out that a high proportion of malnutrition—reflected in weight deficiency—is of an episodic nature. These serial episodes of weight loss then create the long-term nutritional problem reflected in growth deficiency (see, for example, Balderston et al. 1981). Although significantly increasing, too, catch-up growth from a stunted position at the outset occurs much less often than catching up on weight. It should be noted that age of the child is controlled for in this analysis and seasonality is eliminated, as the sample surveys were done at the same time of the two years.

Other results of the regression models presented in Table 49 relate to the effects of food consumption: household-level calorie availability does have a strong positive effect—though decreasing at the margin—on the more short-term indicator of nutritional status (weight-for-height). Current calorie consumption would be an unsatisfactory indicator for the food availability history to which the children were exposed. For this reason, in the long-term model of nutritional status (height-for-age), current calorie

Table 49—Determinants of change in nutritional status and the role of export crop production: multivariate analyses for cohort of children

Explanatory Variable	Change in Weight-for-Age Z-Scores		Change in Height-for-Age Z-Scores		Change in Weight-for-Height Z-Scores	
	Estimated Parameter	t-Value	Estimated Parameter	t-Value	Estimated Parameter	t-Value
Age in months	0.0296	1.60	0.0140	0.74	0.0366	1.79
Age in months squared	-2.548E-04	-1.62	-4.248E-05	-0.27	-3.132E-04	-1.81
Birth order ^a	0.0482	2.72	0.0144	0.82	0.0689	3.54
Sex (male = 1, female = 2)	-0.0226	-0.32	-0.1009	-1.39	0.04133	0.52
Calories per day per adult equivalent, 1985	5.249E-05	0.73	...	...	2.2029E-04	2.78
Calories squared	-5.586E-09	-0.69	...	...	-2.491E-08	-2.76
Breastfeeding ^c	0.2662	1.64	0.1351	0.82	0.3169	1.77
Unsuitable latrine (= 1, else = 0)	-1.212	-0.68	-0.3459	-1.91	0.0556	0.28
Education of household head (years in school)	0.0261	1.28	0.0188	0.92	0.0217	0.97
Z-score of weight-for-age, 1983	-0.5004	-13.48	...	...	...	...
Z-score of height-for-age, 1983	...	...	-0.2672	-7.90	...	...
Z-score of weight-for-height, 1983	...	...	...	...	-0.6984	-17.34
Duration of membership in cooperative (years)	7.694E-03	3.37	0.01237	5.36	1.774E-03	0.70
Constant	-2.278	-3.88	-1.784	-3.10	-1.914	-2.95
R ²	0.360	...	0.229	...	0.469	...
F-value	20.400	...	13.500	...	31.500	...
Degrees of freedom	369	...	371	...	369	...

Note: These analyses are based on a cohort of children who were aged 6-60 months in 1983 and 30-84 months in 1985.

^a First-born child = 1, second = 2, and so forth.

^b The variable is not included in this model because it is not assumed to have an effect on the long-term measure of nutritional status.

^c If child was breastfed = 1 (else = 0).

availability was not included as a variable. To the extent that the new export vegetables increased income, and thus increased household food availability, these results show that the nutritional status of children is likely to be improved, at least in the short run.

POLICY CONCLUSIONS AND GENERALIZATIONS

This study of export crop production in smallholder agriculture is based on experience with a scheme that relies for success on particular conditions described earlier in the report. Clearly the Cuatro Pinos cooperative is an exceptional case of agricultural and rural development and is not typical in Guatemala. However, it is precisely because the cooperative stands out favorably in an environment of numerous failures of agricultural modernization with farmers' participation in Central America that it is possible to arrive at important policy conclusions.

Mellor and Desai (1985, 209) stress that disparities in the distribution of assets and power, which are often based on the social as well as the economic structure, must be recognized. "The need for radical institutional changes may have been overstated in recent years vis-à-vis technological change in agriculture but the necessity for such change must always be examined." Also, their emphasis that "state-sponsored dualism must be guarded against" and that "a full attack must be made on all discriminatory practices that restrain the poor" is of great relevance for this case study.

In studying the effects of increased commercialization of traditional smallholder agriculture in Guatemala, the broader context of the "agrarian crisis" in Latin America, which provides the political and economic environment of this study, should be kept in mind. As de Janvry (1981, 3) puts it, the agrarian crisis in Latin America is characterized by sharply uneven development among farms, crops, and regions, and by massive rural poverty and political tensions. In contrast to the poverty issue in much of Africa, poverty is not a separate phenomenon but is to be seen in terms of its functionality (de Janvry 1981, 149). Low productivity in the traditional sector, unemployment, and regressive income distribution patterns may be identified as direct causes of poverty but are, at the same time, a function of the political-economic systems. As a consequence, de Janvry (1981, 150) points out, policy recommendations regarding poverty run the risk of assuming a reality separate from the functioning of the economic system when they are only directed by idealistic and humanitarian concerns.

Clearly, political and economic structures should be kept in focus when policy conclusions are derived from the case studied here. When the implications of the new export crop production are evaluated here in the context of the existing political-economic system, this is not intended to imply that the effects of this type of export crop scheme are independent of the political system. In a drastic way, this was made clear by the violent repressions that peasant organizations, such as cooperatives, suffered in some parts of Central America in the early 1980s (Williams 1986).

Using Adelman's (1975) term, Guatemala may be a case for "redistribution before growth." Taking a pragmatic evolutionary approach to the problem leads to the derivation of criteria for rural change that work in a desirable direction. Two issues are essential in this respect. The first is the identification of policies that make use of the opportunities for agricultural trade to sustain, not oppose, the relation between growth and distribution. The second is the question classified by de Janvry (1981, 265) as probably the most important one in this context, "whether growth itself is articulating." Does growth through the creation of employment, and hence domestic demand for

wage goods, lead to gradual changes in the production structure that result in "social articulation" of the poor, that is, expressed demand for services, infrastructure, education, and participation in decisionmaking and priority-setting in the development process?

Concerning the first issue—trade opportunities and distribution—the production of export vegetables has worked in the right direction in this study. Some peculiarities of the new crops and the conditions at the location have produced this outcome. Because of their diseconomies of scale in production, nontraditional crops ended up on the smallest farms in the poorest area of the country, creating employment for the small farmers and local landless, substantially increasing real income, and favorably affecting food security and consumption. The favorable effect of the nontraditional crops for small farmers largely depends upon the crops' characteristics, which are very different from those of such traditional export products as cotton, coffee, and beef. These products have apparently positive returns to scale in production and are produced more efficiently on the other end of the dual spectrum of Guatemala's agriculture—the large-scale farm enterprises.

As for the second issue—social articulation—the study finds that institutional changes combined with the expansion of export crop production in a cooperative scheme are forces leading toward social articulation. Noteworthy are the strengthening of cooperation among farmers, increased interaction between village communities, development of local trading and entrepreneurship due to the new crops, and related buildup of economic power in the rural areas by the small-farmer-based economic growth. An earlier discussion (Chapter 4) showed that development assistance can and actually has played a catalytic role in this process. The economic costs of terminating this process are now higher, especially in light of the country's severe foreign exchange problem, which nontraditional export vegetable production plays an important role in alleviating.

No general automation between growth and social articulation of the poor that could lead to development can be postulated based on this study. The study demonstrates the existence of niches in the system that provide this potential and also highlights the specific conditions under which it may work. Central to these conditions are the diseconomies to scale in producing the export vegetables and the ecological conditions in the Western Highlands along with the labor market situation.

The sustainability and expansion potentials of the program depend on the functioning of the marketing channels, domestically and internationally, for both inputs and outputs. The implicit taxation of small farmers through overvalued exchange rates for outputs is a matter of concern. The riskiness of the new crops due to potential disturbances in the marketing chain needs to be a matter of constant attention.

For maximum gains from specialization, policies that ensure efficiently functioning food, labor, and financial markets are the first-best solution. Market imperfections are the worst enemies of sustainable market integration of the subsistence farm sector. As long as market failures cannot be excluded and small farmers' perception of their potential occurrence remains due to past experience (and this may change only slowly), second-best options for policy must be considered. Therefore, the deep-rooted desire for food security achieved by high levels of self-sufficiency at the household level in the Western Highlands can best be accommodated by rapid technological improvements in the traditional subsistence crops—maize and beans—along with expansion of the new export vegetables. This is also a condition for adoption of the new crops and, as observed in this study, small farmers manage to achieve complementarity between growth in the subsistence crops and the new crops.

Accelerated growth in food production alone would have little effect on the general poverty situation in the Western Highlands. Single-minded focus on nontraditional export crops would be risky for small farmers' food security and would be constrained by the adoption problem if food crops did not move jointly.

To cope with production risk and to finance the adoption of the input-intensive new crops, a functioning rural capital market is essential. Rural credit and banking schemes that open up outlets for rural savings are essential for long-term growth. Otherwise, savings find their way into the form of assets—that is, land—with obvious efficiency losses to the initiated development and potential adverse distributional effects at the micro level.

Modest, though statistically highly significant, improvements in nutrition via the favorable income and consumption effects of the program may be expected, as shown by the analysis. This suggests that rapid employment and income growth will make a difference that can be translated into nutritional improvement at the low levels of poverty. The research further suggests that the income-growth effect needs to be supported by appropriate health- and nutrition-oriented social infrastructure. This requires sustained government commitment and community-based actions rather than short-term charity. Development assistance can play an important role if the objective is seen as building up the human capital of the poor.

Given the important role of nonagricultural rural employment in the Western Highlands, the productivity of the growing landless population group depends upon improved human capital, with education and training playing crucial roles. Increasing the human capital stock is also a prerequisite for agricultural productivity to grow in a sustainable way. It is hardly by chance that the early leadership of the export crop cooperative—which the study mainly found to be a success story in the difficult political and economic environment of Guatemala—emerged from intensive primary school courses provided by a local project.

APPENDIX: PROGRAMMING MODEL

Model 1: Precooperative situation

	1	2	3	4	5	6	7	8	9	10	11
	NET	MPRD	VPRD	MSAL	BSAL	VSAL	FRUR	SPUR	FL13	FLA6	FL712
	REVENUES	ha 1	ha 1	kg 1	kg 1	kg 1	kg 1	kg 1	dy 1	dy 1	dy 1
1 LAND	8.750 >	1.000	1.000	1.000	-	-	-	-	-	-	-
2 MYLD	0.000 >	1500.000	-	-	-	-	-	-	-	-	-
3 BYLD	0.000 >	-	-	-	-	-	-	-	-	-	-
4 VYLD	0.000 >	-	-	-	-	-	-	-	-	-	-
5 FERT	0.000 >	271.000	-12760.000	-	1.000	1.000	-	-	-	-	-
6 SP8V	0.000 >	182.000	894.000	-	-	-	-	-	-	-	-
7 LA13	0.000 >	74.000	15.000	-	-	-	-	-	-	-	-
8 LAH6	0.000 >	31.000	43.000	-	-	-	-	-	-	-	-
9 LA712	0.000 >	85.000	51.000	-	-	-	-	-	-	-	-
10 FX13	0.000 >	40.000	279.000	-	-	-	-	-	-	-	-
11 FX46	102.000 >	-	-	-	-	-	-	-	-	-	-
12 FX712	105.000 >	-	-	-	-	-	-	-	-	-	-
13 CREDIT	210.000 >	5.000	128.000	-	-	-	0.340	4.500	-	-	-
14 CPMAX	0.000 >	-	-	-	-	-	-	-	-	-	-
15 STAPL	1383.000 >	1500.000	-	-1.000	-1.000	-	-	-	-	-	-
16 ROTAT	738.000 <	1.000	-1.500	-	-	-	-	-	-	-	-
1 LAND	-	-	-	-	-	-	-	-	-	-	-
2 MYLD	-	-	-	-	-	-	-	-	-	-	-
3 BYLD	-	-	-	-	-	-	-	-	-	-	-
4 VYLD	-	-	-	-	-	-	-	-	-	-	-
5 FERT	-	-	-	-	-	-	-	-	-	-	-
6 SP8V	-	-	-	-	-	-	-	-	-	-	-
7 LA13	-	-	-	-	-	-	-	-	-	-	-
8 LAH6	-	-	-	-	-	-	-	-	-	-	-
9 LA712	-	-	-	-	-	-	-	-	-	-	-
10 FX13	-	-	-	-	-	-	-	-	-	-	-
11 FX46	-	-	-	-	-	-	-	-	-	-	-
12 FX712	-	-	-	-	-	-	-	-	-	-	-
13 CREDIT	-	-	-	-	-	-	-	-	-	-	-
14 CPMAX	-	-	-	-	-	-	-	-	-	-	-
15 STAPL	-	-	-	-	-	-	-	-	-	-	-
16 ROTAT	-	-	-	-	-	-	-	-	-	-	-

[illegible]

Model 3: Postcooperative, with improved productivity in subsistence crops

	NET REVENUES	1 MPRD ha 1	2 SPRD ha 1	3 VPRD ha 1	4 MSAL kg 1	5 BSAL kg 1	6 VSAL kg 1	7 FPU9 kg 1	8 SPUR kg 1	9 FL13 dy 1	10 FL46 dy 1	11 FL712 dy 1
1 LAND	0.750 >	1.000	1.000	1.000	1.000							
2 MYLD	0.000 >	-2100.000										
3 BYLD	0.000 >		-1171.000			1.000						
4 SYLD	0.000 >											
5 VYLD	0.000 >						1.000					
6 FERT	0.000 >	287.000	298.000	-12760.000				-1.000				
7 SPRT	0.000 >			694.000								
8 LA13	0.000 >	31.000	83.000	15.000								
9 LA46	0.000 >	52.000	57.000	43.000								
10 LA712	0.000 >	40.000	15.000	175.000								
11 FX13	105.000 >			229.000								
12 FX46	105.000 >											
13 FX712	210.000 >											
14 CREDIT	0.000 >	5.000	57.000	128.000				0.340	4.500			
15 CRMAX	1583.000 >											
16 STAPL	736.000 <	2100.000	1171.000		-1.000	-1.000						
17 ROTAT	0.000 <	1.000		-1.500								
1 LAND												
2 MYLD												
3 BYLD												
4 SYLD												
5 VYLD												
6 FERT												
7 SPRT												
8 LA13												
9 LA46												
10 LA712												
11 FX13												
12 FX46												
13 FX712												
14 CREDIT												
15 CRMAX												
16 STAPL												
17 ROTAT												

Notes: 1) The opportunity cost of land is computed on the basis of fixed land supply. Land rental is not allowed for in the model. The model is simply built for the "average" farm as described by the sample survey data. A refined approach would certainly entail modelling the farm interactions in the study area between coop and noncoop farmers and the related land and labor market effects.

2) The programming model was solved using the following package: Mve College micro-linear programming package, version 4.0, May 1985, developed by J. P. G. Webster, B. J. George, and P. A. Kentish.

Variables in the Programming Model

<u>Activities</u>		<u>Constraints</u>	
MPRD	= production of maize	LAND	= farm size
BPRD	= production of beans	MYLD	= yield of maize
VPRD	= production of vegetables (traditional)	BYLD	= yield of beans
SPRD	= production of snowpeas	SYLD	= yield of snowpeas
MSAL	= sales of maize	VYLD	= yield of vegetables (traditional)
BSAL	= sales of beans	FERT	= fertilizer use required
VSAL	= sales of vegetables (traditional)	SPRY	= spraying material use required
SSAL	= sales of snowpeas	LA13	= labor required in January-March
FPUR	= purchase of fertilizer	LA46	= labor required in April-June
SPUR	= purchase of chemicals for spraying	LA712	= labor required in July-December
FL13	= use of family labor on farm in January-March	FX13	= family labor available in January-March
FL46	= use of family labor on farm in April-June	FX46	= family labor available in April-June
FL712	= use of family labor on farm in July-December	FX712	= family labor available in July-December
ML13	= hiring in of labor in January-March	CREDIT	= financing requirement
ML46	= hiring in of labor in April-June	CRMAX	= collateral upper limit
ML712	= hiring in of labor in July-December	STAPL	= staple food for consumption from own production desired
OF13	= off-farm work of family labor in January-March	ROTAT	= rotational constraints
OF46	= off-farm work of family labor in April-June		
OF712	= off-farm work of family labor in July-December		
FIN	= financing input acquisition and hired labor		

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RESEARCH REPORT

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FOOD PRODUCTION IN A LAND-SURPLUS, LABOR-SCARCE ECONOMY: THE ZAIRIAN BASIN

Tshikala B. Tshibaka

June 1989

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**FOOD PRODUCTION
IN A LAND-SURPLUS,
LABOR-SCARCE ECONOMY:
THE ZAIRIAN BASIN**

Tshikala B. Tshibaka

**Research Report 74
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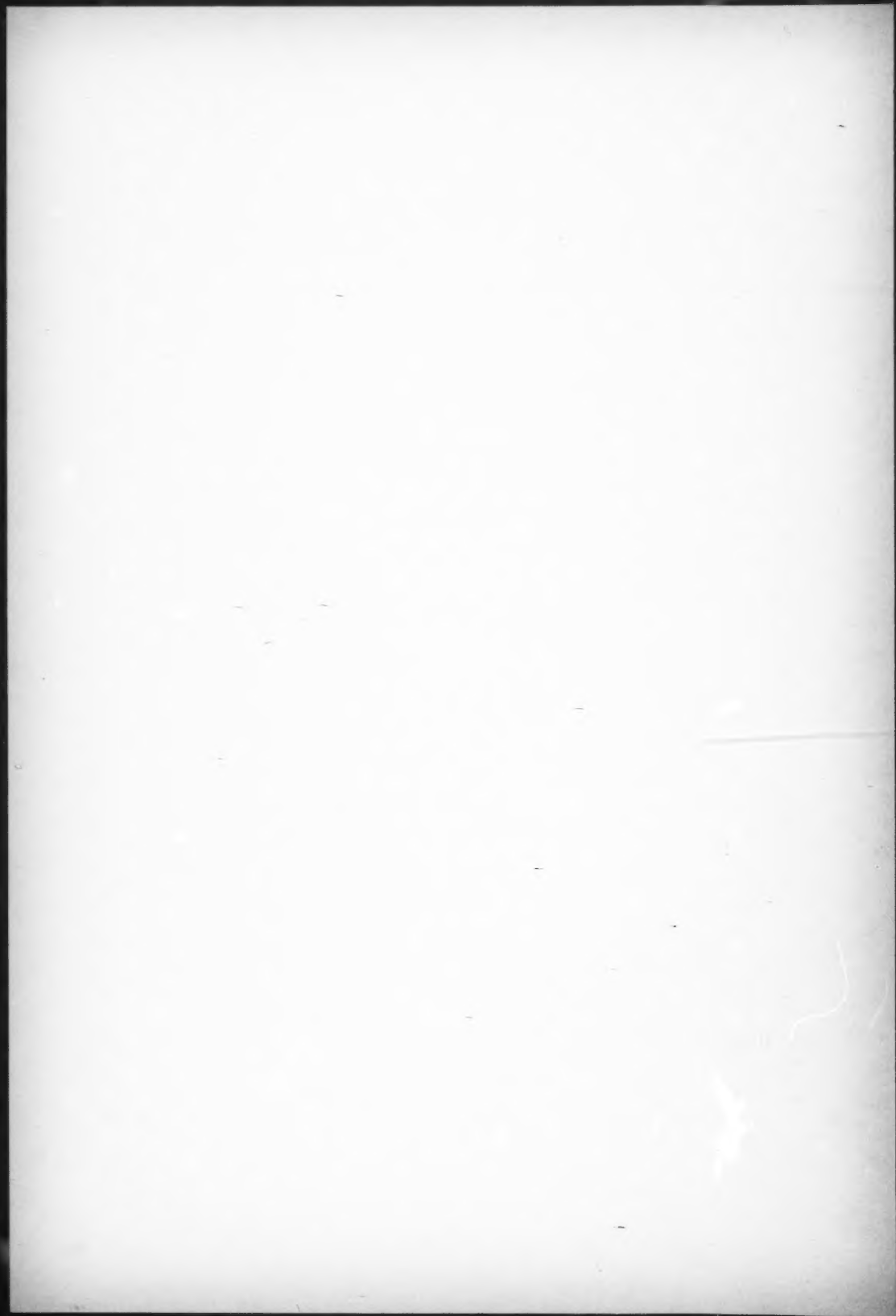
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FOREWORD

Once a net food exporter, Sub-Saharan Africa is now the only major area of the world where the per capita food supply has been declining for the last two decades. Despite massive food imports and aid, the deterioration of the food sector, coupled with rapid population growth, has caused many Africans to face food shortages and other hardships.

The agricultural policies followed in many parts of Sub-Saharan Africa have played an important role in moving the region from a net food exporter to a net food importer. This report on food production in Zaire is the first in a series of studies being undertaken by the Food Production Policy Program at IFPRI on factors impeding food production in the smallholder sector of the region.

In this research report, Tshikala B. Tshibaka describes the state of the small-farm sector in the Zairian Basin and identifies different constraints affecting productivity and hence the volume of food output this sector produces. This study not only adds to our knowledge of the Zairian economy, but it also constitutes a useful addition to the information bank that policymakers need in order to formulate consistent agricultural policies.

The Zairian Basin represents an important agroecological region in Africa, that, as is clear from the report, has immense problems that should be studied if the many people in the region are to participate actively in the development process. We particularly hope that this research, appropriately modified, will serve as a prototype for further analyses of the conditions for improvement.

This study, conducted in collaboration with the Institut Facultaire des Sciences Agronomiques (IFA), Yangambi, Zaire, was partially funded by the International Development Research Centre of Canada (IDRC). IFPRI and IFA are grateful to IDRC for its encouragement and consistent support of this and other research work on Sub-Saharan Africa.

John W. Mellor

Washington, D.C.
June 1989

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Finally, the author strongly appreciates the help of his former graduate assistants, Muimane-Muende Kalala and Muhiya Aunge, at the Institut Facultaire des Sciences Agronomiques, who helped during the earlier stages of this study.

SUMMARY

Most agricultural projects initiated by the government of Zaire in the small-farm sector during the last two decades to improve a worsening food supply situation have failed mainly as a result of limited knowledge about constraints affecting the development of the sector. This study was undertaken to fill this gap. The study area is located in the Zairian Basin, which is part of a tropical rain forest zone. The zone includes large parts of Equateur, Haut-Zaire, Sud-Kivu, Maniema, Kasai Oriental, Kasai Occidental, and Bandundu regions, and a small part of the Bas-Zaire region. The Basin also extends beyond the Zairian boundaries to include a part of the Congo.

The Basin is ecologically more suited to perennial (tree) crops than to annual (food) crops. Most robusta coffee, cocoa, natural rubber, and palm oil trees are grown on plantations. The area is the major zone in the country for growing tree crops, as well as rice and plantain. Small-farm households primarily grow staple food crops, mainly rice, maize, cassava, and plantain.

Land is readily available in this sparsely populated zone. The mode of farming used by small farmers in the production of food crops is the slash-and-burn fallow system. Because of the fragility of the soils, a long fallow period is called for, preferably after every cropping season. Consequently, labor is required each crop year to open new plots of cropland by slashing, burning, and clearing. The poor state of roads and other infrastructure severely limits marketing possibilities for crops.

The study points up two basic facts: the amount of resources, particularly labor, allocated to farming in the Zairian Basin is small, even by African standards, and the productivity of these resources is also low. During the 1982/83 crop year, an average of 271 man-hours was devoted to agriculture per man-equivalent (which takes into account differences in age and sex) out of 776 man-hours devoted to economic activities. Farming's share of productive labor time was only about 34.9 percent. The remaining work time was allocated to hunting, fishing, gathering, handicrafts, and commerce. The study also reveals that only a small amount of capital was allocated to farming, and this was limited to a few hand tools and rice and maize seeds produced on-farm. On average, each household spent about 75.40 zaires (Z) on tools and Z25.34 on seeds during the 1982/83 crop year (Z5.75 equaled US\$1.00 in 1982/83). Because so little labor and capital (tools) were allocated to land preparation, the amount of area cultivated was also severely limited. A 1.00 percent increase in labor devoted to land preparation would increase cultivated area by 0.75 percent, and a 1.00 percent increase in tools would increase it by 0.25 percent. As it was, cultivated area per household was only 0.67 hectare, about 0.22 hectare per man-equivalent.

The analysis also indicates that, despite the small area cultivated, the amount of labor input per hectare was high compared with other parts of Sub-Saharan Africa and Asia—about 1,230 man-hours per hectare during the 1982/83 crop year. Overall, a 1.00 percent decline in cultivated area would increase labor use per hectare by 0.42 percent.

In the study area, labor was more productive on cassava and plantain than on rice and maize. The average product of labor was about 0.58 kilogram of cereal-equivalents per man-hour for rice and 1.22 kilograms for maize in 1982/83. For cassava, the productivity of labor was 6.62 kilograms and for plantain, it was 3.17 kilograms of

cereal-equivalents per man-hour. Overall, the productivity of labor input was estimated at about 3.08 kilograms in cereal-equivalents per man-hour, and labor input was the major contributor to overall food crop output in the Zairian Basin. Labor contributed 78 percent to food crop output and capital contributed 22 percent.

The study indicates that, given the current agricultural resource base, the productivity of labor input could be significantly increased if each household in the area were to allocate more labor to farming, especially to land preparation, because labor productivity increases with the size of cultivated area. Domestic terms of trade between crop and noncrop products and the availability of capital are the key variables affecting the amount of labor allocated to farming in the Zairian Basin. The elasticity of labor input devoted to farming per man-equivalent with respect to the domestic terms of trade of farm relative to nonfarm products was 0.38 and that with respect to capital input was 0.28.

Policies to improve domestic prices for farm products and the amount of capital input should include development of infrastructure such as roads; transportation, distribution, and marketing facilities; and rural capital markets. In addition, investments in new technology such as improved seeds and fertilizers offer some opportunity for improvement, particularly in the production of cereals in the area.

INTRODUCTION

Background and Objectives of the Study

Since the 1970s, per capita food and agricultural output in Sub-Saharan Africa have been declining as a result of the low land and labor productivities that characterize African smallholder agriculture. Economic studies have mostly approached the development problems of smallholder agriculture in terms of land-labor relationships, and in so doing, they have underestimated the role of capital in the development process (Cleaver 1974; de Wilde 1967). These studies have at least partly influenced agricultural policies and led many policymakers to believe that food and agricultural output can be increased mainly through land expansion. As a result, the introduction of capital inputs (such as fertilizer, high-yielding seeds, pesticides, irrigation, and equipment) and improved agricultural techniques in the small-farm sector, as well as the development of physical infrastructure and rural institutions, have received limited attention. This largely explains why the productivity of land and labor is currently so low.

In comparison, in Asia, where land expansion is no longer a feasible solution to growth in food and agricultural output as a result of high population pressure, researchers and policymakers reached a consensus that a fundamental structural change in the land-labor-capital relationship had to be initiated if a respectable growth in food and agricultural output was to be achieved. In the process, this consensus led to a policy framework that promotes extensive use by smallholders of capital inputs, which encompass both land-augmenting and labor-consuming technologies. This technological change has led to a substantial upward shift in the productivity of both land and labor in Asia (Hayami and Ruttan 1985; Mellor 1976).

Evidence pertaining to Sub-Saharan Africa suggests that the expansion of cultivated area in the region resulted in a modest increment in food output during the 1961-80 period, while the share of yield increase in the growth of food output was negligible (Paulino 1987). Consequently, the rate of growth of food output has not kept pace with population growth in the region. This situation has led to massive food imports, which have drained limited foreign exchange earnings and hence constrained the ability of the countries in the region to improve and expand the productive capacity of agriculture and of the rest of the economy.

Zaire is one of the countries in Sub-Saharan Africa where the food supply situation has been deteriorating at an alarming rate for at least two decades. The annual average growth rate of domestic staple food crop output, which was about 4.0 percent during 1966-70, declined to 1.6 percent during 1971-81. The annual average growth rate of cereal imports decreased from 11.2 percent during 1966-70 to 10.4 percent during 1971-81, due to restrictive trade and exchange rate policies. The annual average growth rate of the total staple food crop supply (including imports) declined from 4.1 percent during 1966-70 to about 1.8 percent during 1971-81, while the annual population growth rate was about 2.8 percent during the period (Tshibaka 1986).

The widening gap between food supply and population growth has created hardships for many of the people of Zaire. A 10-year field study on nutrition and health revealed that malnutrition has been spreading rapidly (World Bank 1980). Average calorie intake was only 80-90 percent of minimum requirements, indicating that food production

and imports fell short of meeting growing food needs. To reverse the trend, the Zairian government initiated a number of agricultural projects, including programs to expand production of rice, maize, cassava, and pulses, and introduction of grain marketing boards and farmer cooperatives. Most of these projects failed to meet expectations (Kapambwe 1974; Lititiyo 1977). Limited empirical evidence indicates that they were formulated and implemented with little knowledge about key constraints affecting the development of the small-farm sector. For example, in the rain forest zone known as the Zairian Basin, it was found that the pattern of labor allocation among different household activities constitutes one of the major constraints to increased farm output. A survey conducted in 1974/75 on a small sample of 17 households in the Zairian Basin, specifically in Yalibwa, Turumbu Community, indicated that farming claimed only 11 percent of adult male labor time and 27 percent of adult female time (Tshibaka 1975).

A detailed study of the farming system was needed to reveal not only the key determinants of labor allocation, but also other major constraints to increased food output. To this end, this study examines the following basic questions. First, what is the household resource base for small farmers? Second, how are these resources allocated between farming and nonfarming? Third, what are the key determinants of this resource allocation, and what are the implications for the farm sector? And fourth, what is the level of resource productivity, and what actions need to be initiated to improve it?

Data Source and Limitations

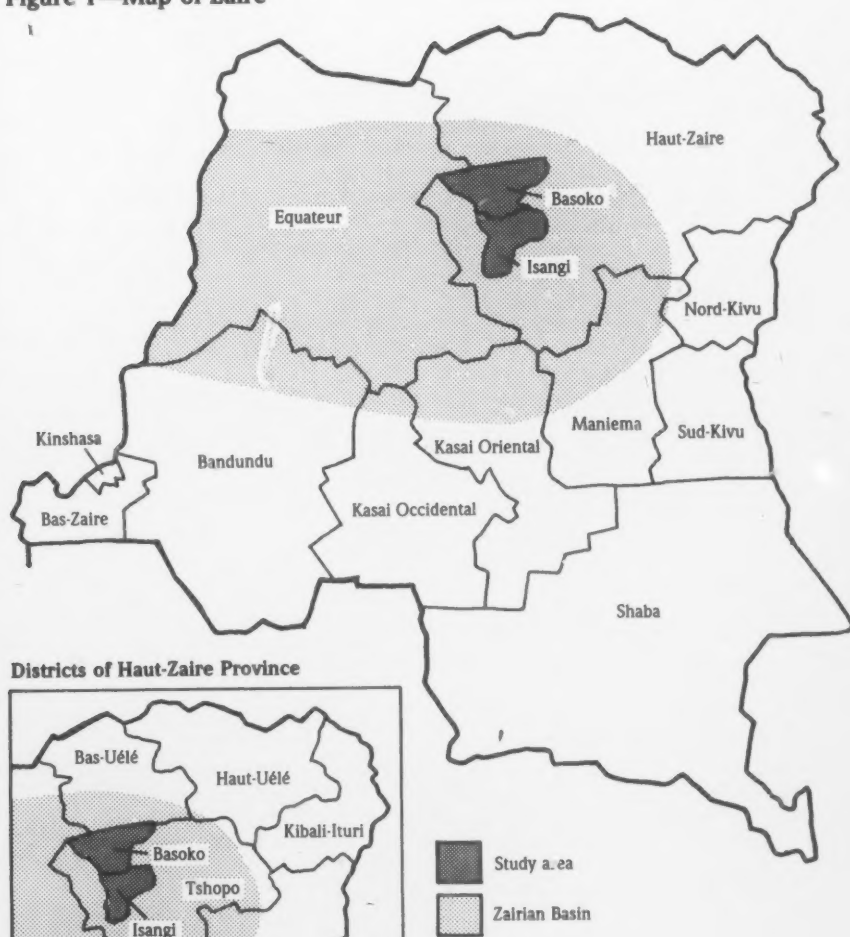
A joint study by the Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and the International Food Policy Research Institute, Washington, D.C., was undertaken with the support of the International Development Research Centre of Canada to provide basic data that could help the government of Zaire formulate consistent agricultural policy to enhance the production of rice and other food crops in the Zairian Basin in particular and in the country as a whole.

The Zairian Basin is part of a tropical rain forest that covers almost 40 percent of the Zairian land area. Tree crops—robusta coffee, palm oil, rubber, and cocoa—are mainly grown in this forest zone. The zone is also the major growing area for rice, cassava, and plantain in the country. Zaire is currently divided into 11 regions (provinces): Kinshasa, Equateur, Haut-Zaire, Maniema, Nord-Kivu, Sud-Kivu, Shaba, Kasai Oriental, Kasai Occidental, Bas-Zaire, and Bandundu. The rain forest includes a part of each of these provinces, except Kinshasa and Shaba. Each province (region) is, in turn, divided into districts (subregions) and each district into zones (counties).

The data used in this research report were derived from a cost route survey conducted from September 1982 to August 1983 by the author in Turumbu, Mongandjo, and Bomaneh rural communities located in Isangi and Basoko zones, Tshopo District. This subregion is located in the rain-forest part of Haut-Zaire Province (see Figure 1).¹ The study area covered in the survey was divided into six subareas on the basis of available infrastructure (the road network system), and a sample of 180 households, 30 from each subarea, was drawn. To increase the sample efficiency (to lower the sampling variance), the 30 households were chosen following a proportionate, stratified

¹ This type of survey has been widely used in Africa. For detailed information, see: Purdue University (1980), Zuckerman (1979), Matlon et al. (1979), Shapiro (1973), Norman (1973a), Elliott et al. (1970), and Winch (1976).

Figure 1—Map of Zaire



Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

sampling procedure (Rossi et al. 1983; Upton 1973). First, a number of villages were randomly drawn in each subarea. Second, taking account of the population of selected individual villages, a given number of households were randomly drawn in each village.

One enumerator and an aide were posted in each subarea for one crop year. Two research assistants were allocated to the project to help supervise the survey. Selected households were visited by enumerators four times a week for one crop year and two techniques of data collection were used: interview and direct measurement. For various reasons, 48 households did not provide all the required data, and were eliminated. Hence, at the end of the survey, data from only 132 households were retained. Data were collected on population, infrastructure, input, output, and prices. Enumerators measured perimeters and triangles of land under crops using tape measures, compasses, and pickets, and cultivated area was estimated by the triangulation method.

The most serious limitation of this type of survey has always been the assessment of time spent on different activities, which is affected by farmers' own judgment and that of the enumerators. With regard to capital, farmers do not easily recall the monetary value of their tools and the date of acquisition. These limitations are hard to avoid in a situation where most farmers are illiterate or do not keep records.

In a system where mixed cropping is the most prevalent mode of production, the estimation of cultivated area, labor, and capital allocated to individual crops presents a number of unresolved practical and methodological problems. To circumvent these difficulties, the researcher is tempted to convert all food crop outputs into cereal equivalents and to proceed with the computation of input/output relationships without having an idea of how much area is allocated to individual crops. This approach is inappropriate for a number of reasons. First, there is a hierarchy of crops in mixed cropping. There are major and minor crops in the same field. For example, other things remaining the same, a field sown mainly with rice is different from a field mostly planted with cassava, both in resource requirements and yields expressed in cereal equivalents. Hence, an estimate of the share of area allocated to each crop is indispensable for reflecting the effects of various crop mixes. Second, it would be difficult to answer a number of crop-specific questions that are of policy interest if crops were lumped together, such as the productivity of resources used in the production of individual crops.

A statistical method proposed by the Institut National des Statistiques et d'Etudes Economiques de France was adopted to estimate the cultivated area allocated to individual crops. For a description of this method, see Appendix 1. The proposed method, notwithstanding its limitations, provides estimates that are useful when studying a mixed-crop farming system (Norman 1972).

The allocation of time spent on nonspecific farm operations such as land preparation and weeding among individual crops was performed on the basis of area shares of individual crops. For capital tools—mainly hoes, cutlasses, and hatchets—the labor time allocated to each of the four crops expressed as a fraction of total labor time devoted to farming was used as a weight to calculate the depreciation of capital tools (in zaires) used in the production of each of the crops. This approach is supported by the fact that most of the tools used in the area are hand-held; therefore, their use is highly correlated with labor input per crop. For example, tools must be used much more extensively on 1 hectare of rice than on 1 hectare of plantain. To estimate crop densities and yields, a yield plot method was used (see Appendix 1).

3

THE STUDY AREA

Ecology of the Study Area

The study area is part of the Zairian Basin, a forest zone in the humid tropics of Africa. Rainfall averages about 1,800 millimeters a year with bimodal precipitations. There are two rainy seasons—one between March and May and the other between August and November—and two dry seasons—one between January and February and the other between June and July.

The area receives an average of 1,972 hours of sunshine per year, representing 45 percent of the days of possible sunshine, most of it concentrated during the drier periods of the year. The limited sunshine constitutes an important ecological constraint to crop production. Temperatures in the area average 25.5° C (Crabbe 1970; Bernard 1945).

Soils are leached. High surface heat and hard, frequent rains lead to rapid breakdown of organic soil materials (Sanchez 1976). As a result, fertility is low. Once land is cleared and put under cultivation with annual crops, soils are rapidly depleted. The forest that covers the Zairian Basin is rich in flora and fauna. Birds, pests, and diseases constitute a major environmental threat to food crop production in this area.

Small-Farm Agriculture in the Zairian Basin

The small-farm sector, the core of this study, includes subsistence-oriented farmers who cultivate less than 5 hectares of land each crop season. Inputs are limited to simple hand tools such as cutlasses, hoes, and hatchets, on-farm crop seeds, and household labor. Use of hired labor is uncommon in the area. Land is abundantly available to every household. All the staple food crops—cassava, plantain, maize, and rice—are produced under a mixed cropping system.

Small-farm production of robusta coffee is negligible and production of cocoa and natural rubber by small farmers is almost unknown. None of the households selected in the sampling process produces coffee. A substantial share of households, however, exploit wild palm oil trees. Since the palm oil tree is a native of tropical Africa's rain forest, which includes the Zairian Basin, the small farmer's production of palm oil is considered to be a gathering rather than a farming activity. As for livestock, the rain forest zone of Sub-Saharan Africa is not suitable, especially for cattle raising, because of the tsetse. Although a few households keep a small number of goats, pigs, or chickens, livestock raising as an economic activity is negligible. The study area derives most of its animal protein requirements from hunting and fishing.

The forest area of the humid tropics of Africa is ecologically more suitable to perennial (tree) crops than to annual (food) crops (Jurion and Henry 1967). Since the colonial era, the Zairian Basin has been the major tree-growing area in the country. The main tree crops produced are robusta coffee, cocoa, natural rubber, and palm oil for export. These crops are mainly produced on privately owned, large-scale plantations, using modern equipment and machinery, hired labor (who live on the plantations), and modern agricultural and managerial techniques. Because roads in the study area have deteriorated drastically, few plantations are now operating there.

Tree crop agriculture uses the land—the most abundant resource in the country—most intensively, and it approximately recreates the natural environment by replacing the natural forest with an artificial one made up of tree crops. As such, its negative effect on the environment, particularly on soil and forest conservation, is small. In contrast, small-farm agriculture uses the land extensively under a shifting mode of cultivation. That is, the same farm fields are planted with a mix of rice, maize, cassava, and plantain. Maize is harvested three months after sowing, and rice in four, whereas cassava and plantain occupy the land for a period that extends into the new cropping season, hence compelling farmers to open new plots of forest or fallow at the beginning of each cropping season. When cassava and plantain crops are harvested, the fields are then left fallow. Under this cassava-based system, farm fields are generally cropped for one season and then left fallow for a number of seasons.

It follows then that, from a long-run ecological standpoint, in the Zairian Basin, the appropriate small-farm agriculture to promote is a tree crop production system. Once food markets begin to operate adequately, small farmers could purchase food, but in the short run food can be produced for home use at much lower factor returns than in tree crop production. The logical tree crops to promote among small farmers are palm oil, coffee, and cocoa.

The first step in an effort to enhance regional crop specialization in the country is to initiate a well-planned, long-term investment program to develop infrastructure such as roads, river transport, and distribution and marketing channels.

Study Population

The study area, located in Haut-Zaire Province, Tshopo District, includes three communities: Turumbu people in the administrative zone of Isangi; Basoo people in Bomaneh, Bomenge Rural Community; and Bangelima people in Mongandjo Community in the administrative zone of Basoko.

These ethnic groups mainly depend on farming, hunting, gathering, and fishing for their living. The total population of the area was estimated at 49,103 people in 1981. Its annual population growth rate was estimated at about 1.2 percent, which was substantially lower than the national average growth rate of 2.8 percent per year (Zaire 1983).

Data are drawn from 53 households in Turumbu Community, 53 households in Mongandjo, and 26 households in Bomaneh, Bomenge Community (see Table 1). The sample population of 885 people is 48.1 percent male and 51.9 percent female.

The most productive age group, the 20-55 age bracket, accounts for 16.5 percent of males and 22.7 percent of females. The 15-19-year-olds, the group that will be most productive in the near future, includes 4.1 percent of the males and 3.4 percent of the females. The age groups under 15 and above 55 account for 27.6 percent of the males and 25.8 percent of the females.² The sample population of 885 people represents a total labor force of 400.8 man-equivalents of which 217.6 are males and 183.2 are females. The factors used to convert people of different ages and sexes to man-equivalents are given in Appendix 1.³ This gives an average of 3.9 man-equivalents per household in Turumbu, 2.5 in Mongandjo, 2.4 in Bomaneh (Bomenge), and 3.0 in the study area

² In Zaire, farmers more than 55 years old are regarded as retired.

³ For more details see Collinson (1972). The total number of man-equivalents per household are given in Appendix 1, Table 28.

Table 1—Structure of the sample population in the study area

Sex/ Age Group	Turumbu Villages			Mongandjo			Bomenge	Study Area Total	
	Yangambi-Kisangani Road ^a	Weko and Yambaw	Yangambi-Isangi Road ^b	Total Turumbu Community	Bolikongo	Babendja	Total Mongandjo Community		Bomanah
(number of people)									
Males									
Less than 1 year old	2	3	0	5	1	0	1	6	12
1-4 years	12	15	9	36	12	6	18	8	62
5-9 years	9	9	12	30	13	12	25	14	69
10-14 years	13	8	6	27	3	9	12	9	48
15-19 years	14	5	6	25	6	1	7	4	36
20-55 years	26	24	27	77	21	21	42	27	146
More than 55 years old	5	10	8	23	12	16	28	2	53
Total males	81	74	68	223	68	65	133	70	426
Females									
Less than 1 year old	2	6	4	12	3	3	6	7	25
1-4 years	9	5	9	23	6	7	13	14	50
5-9 years	12	12	13	37	9	11	20	9	66
10-14 years	7	8	5	20	3	8	11	9	40
15-19 years	5	9	9	23	4	0	4	3	30
20-55 years	34	31	30	95	35	34	69	37	201
More than 55 years old	6	9	4	19	14	14	28	0	47
Total females	75	80	74	229	74	77	151	79	459
Total number of people	156	154	142	452	142	142	284	149	885
Number of households	17	17	19	53	25	28	53	26	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

^a Households in this group are located along the Yangambi-Kisangani Road up to 22 kilometers from Yangambi.

^b Households in this group are located along the Yangambi-Isangi Road up to 20 kilometers from Yangambi.

as a whole. The 20-55 year age group, relatively more involved in farming, accounts for 70.0 percent of the overall sample of which 36.4 percent are males and 33.6 percent females.

Basic Infrastructure in the Study Area

The Zairian Basin is the least developed region in the country, which is reflected in the poor state of the road network and consequently the transportation system.

Most villages in the region are isolated or poorly connected to major markets and urban centers. There are differences from one group of villages to another in physical condition of the roads and distances to rural markets or urban centers, making some villages more accessible than others. Most Turumbu villages are served by the Zaire River and the Isangi-Yangambi-Kisangani road. Local traders provide the sole means of transportation on the river, the traditional canoe. The traders are Lokele people, who play an important role in the distribution and marketing of farm and nonfarm commodities produced by Turumbu farmers. Although canoes are used all year round, the volume of goods transported remains small, and the risk of shipwreck high.

The Isangi-Yangambi-Kisangani road, considered to be a major national road, is unpaved. Even during relatively dry periods of the year, the use of this road by vehicles is limited. The 97 kilometers that separate Yangambi and Kisangani may be covered in three hours in the best of weather conditions. During wet periods, the road is seldom used by vehicles. The high level of precipitation in the Zairian Basin makes the use of unpaved roads by vehicles difficult during most of the year. As a result, Turumbu villages along this axis are poorly connected to Yangambi and Lotokila—the major local markets in the community—as well as to Kisangani, the major urban center. Farmers living along this road usually walk 4-23 kilometers, depending on the location of their villages, to reach a rural marketplace.

A second group of Turumbu villages, even more isolated, includes Weko and Yambaw in the remote forest. The road connecting these villages to Yangambi has deteriorated to such an extent that it is no longer used by vehicles at all. Farmers bring their produce twice a week to a local marketplace (which is 1 kilometer from Weko and 12 kilometers from Yambaw) for sale to traders, most of whom come from Yangambi by foot or bicycle. The distance from this local market to Yangambi is about 42 kilometers.

In Mongandjo Community, farm households are served by the Aruwimi River and two feeder roads. The 42-kilometer road connecting Bolikango to Basoko is the best maintained in the entire study area. It was in fair condition for seven months of the survey year, in poor condition for three months, and in very poor condition for two months. Farmers walk on foot 5-23 kilometers to reach three rural markets: Longote, Bokote, and Baonde. The first two rural marketplaces are along the Aruwimi River, while the third one is at the point where the Basoko-Baonde route crosses the Aruwimi River. Farm and nonfarm products sold there are transported by traditional canoes or vehicles to Basoko, an important river port and marketplace.

The 190-kilometer road connecting Babendja in Mongandjo Community to Basoko is the second best road in the area. This road was in fair condition for five months, and in poor or very poor condition for the rest of the 1982/83 crop year. Babendja farmers walk 4-13 kilometers to reach a local market, where farm and nonfarm products are sold and transported to Basoko either by road or by the Aruwimi River. The Aruwimi River is used all year round by small boats and canoes. The distance by water from Babendja to Basoko is about 105 kilometers.

The 21-kilometer road connecting Bomaneh to Basoko in Bomenge Community is no longer practicable for vehicles, and it is now left entirely to those on foot. Only the Aruwimi River connects Bomaneh farmers to the two marketplaces, Baonde, 23 kilometers away, and Basoko, 24 kilometers. Canoes and small boats are the means of transportation used by farmers to reach these rural marketplaces.

Table 2 summarizes data on the conditions of the roads and the navigability of rivers in the area. It shows that Mongandjo and Bomaneh (Bomenge) farmers are in a somewhat better position than Turumbu farmers. The negative impact of this poor road network on the development of local marketing channels cannot be overemphasized. In all, the transportation system in the study area is grossly inadequate. For this and other reasons, few plantations are now operating in the study area, and none of the surveyed households were employed by plantations. This low level of infrastructural development constitutes one of the most important constraints to increased food and agricultural output in the area.

Distribution, Marketing, and Pricing of Farm Products

The distribution, marketing, and pricing of farm and nonfarm products were regulated under different policy regimes until September 1983, when prices of all farm and most nonfarm products were liberalized, and restrictions imposed on domestic trade were lifted (Tshibaka 1986).

The distribution of cassava, plantain, other root and tuber crops, game meat, fish, handicrafts, and products from gathering have never been controlled by the Zairian government. The demand and the supply of these products were and continue to be

Table 2—Practicability of roads and navigability of rivers in the study area, 1982/83 survey

Transport Route Destinations	Condition of Road/River			Distance from Primary (Local) to Secondary Markets	Community Served	Villages Served
	Fair	Poor	Very Poor			
	(number of months)			(kilometers)		
Yangambi-Kisangani road	0	5	7	97	Turumbu	Villages along the Yangambi-Kisangani road
Yangambi-Weko	0	0	12	42	Turumbu	Villages in remote forest (Weko and Yambaw)
Yangambi-Isangi road	0	5	7	97	Turumbu	Villages along the Yangambi-Isangi road
Basako-Baonde road	7	3	2	47	Mongandjo	Bolikango
Basoko-Mongandjo (Aruwimi River)	8	4	0	105	Mongandjo	Babendja
Basoko-Bomaneh (Aruwimi River)	8	4	0	24	Bomenge	Bomaneh

Source: Based on data from Tshibaka B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Economiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: For rivers, "fair" indicates navigable and "very poor," not navigable.

regulated by domestic market forces. But crops such as rice, maize, groundnuts, cotton, coffee, tea, palm oil, cocoa, and rubber were subject to government control until September 1983.

Due to the poor state of the road network in the study area, the distribution, marketing, and pricing of rice and maize were not totally enforced. But rice millers who were able to reach the villages applied some political pressures to persuade farmers to accept the official price for their paddy rice. A substantial portion of paddy, however, was and still is converted into rice at the household level, using mortar and pestle. This is the traditional method used in every part of the country where rice is grown. Although the method produces a low-quality product from a commercial standpoint with a significant amount of broken rice, the nutritional value of the rice is preserved, as most vitamins and minerals are retained. This rice product is sold by female farmers in the local market to any potential trader or consumer at the market price. Regarding maize, most of it is converted into an alcoholic drink favored in the study area. The price of this drink is determined by local market conditions. Rice and maize are the major source of cash income from farming in the study area.

At the local level, three groups of participants carry out most of the distribution and marketing of farm products. These include farmers, small transporters, and petty traders, most of whom are women. Cassava products offered for sale by farmers are fresh roots, dry roots, *chickwangue* (cassava bread), and leaves (Tshibaka and Lumpungu 1989). Fresh plantain, paddy rice, milled rice, and maize grains are the most common forms in which plantain, rice, and maize are offered for sale by small farmers. Because the infrastructure—roads and other transportation facilities—is inadequate in the study area, leaves, fresh cassava roots, *chickwangue*, and plantain have a limited marketing area. Being the most perishable, they are generally sold in the local markets. From this description, the critical role of infrastructure in distribution and marketing is apparent, as well as the need to promote the processing of farm produce into products that can be stored and marketed over long periods of time.

LAND AND CAPITAL INPUTS

At the outset, it should be noted that this study is based on an implicit assumption that all the resources allocated to the small-farm sector are used up in the production of the four major crops, namely rice, maize, cassava, and plantain. Although minor crops such as vegetables and fruits are also produced, they are not considered here.

Land and Related Aspects

Land Tenure System

Although the constitution of Zaire stipulates that land and all natural resources belong to the state, Zairian ethnic groups still consider certain lands their property. In the study area, all of the household heads interviewed affirmed that all members of the clan, regardless of sex, religion, or political affiliation, have free access to land and other natural resources (forests, streams, and rivers) belonging to the clan. These resources are common property and cannot be alienated.

The traditional land tenure system in the area, however, seems to be tacitly moving toward private ownership of land. Sixty-four percent of the surveyed household heads interviewed affirmed that every household retains the right to use their fallow land. This right is extended to household male descendants. In practice, this amounts to private ownership of land. One should note that this practice does not imply that land is scarce in the area. Indeed, the population density does not exceed five persons per square kilometer.

Furthermore, the survey shows that in Turumbu Community payment in cash or kind by nonmembers of the clan is accepted where the right to fallow land is recognized.⁴ Among Bangelima and Basoo in Mongandjo and Bomenge, there is no correlation between payment and the right to use fallow land. Table 3 presents this data. It should be stressed that payments are in no circumstances regarded as a sale price of land or as rent.⁵ From the traditional point of view, land cannot be bought or sold. It remains a common property of the clan, and the nonmember is allowed to use it as long as he lives with the clan or has not fallen under disgrace.

These are only a few aspects of the complex traditional land tenure system related to farming, which varies from one clan to another within the same ethnic group. A common feature of all these traditional land tenure systems is that land and other natural resources are common property.

Regarding the government's role in land use and management, 69.6 percent of farmers interviewed believed that the government should play a monitoring role. The rest of the farmers considered government intervention likely to create additional problems.

⁴ The first household to open a piece of land keeps the right to use that land as long as household members continue to live in the village, unless they state explicitly that they are no longer interested in it. At that time, the land returns to the common pool.

⁵ The payment is made only once, which differs from rent that has to be paid continuously as long as the land is being used. It is given by the nonmember of the clan in appreciation for the right to use the land, which the clan has extended.

Table 3—Community recognition of practices of right of fallow and lease of land to nonmembers in study area

Rural Community	Number of Household Heads Interviewed	Community Accepts Payment for Land	Community Recognizes Right of Fallow
		(percent)	
Turumbu			
Yangambi-Kisangani road ^a	17	65.4	100.0
Weko and Yambaw	17	4.8	9.0
Yangambi-Isangi road ^b	19	23.8	60.0
Mongandjo			
Bolikango	25	0.0	8.0
Babendja	28	7.1	25.0
Bomenge			
Bomaneh	26	0.0	80.8

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

^a The households in this group are located up to 22 kilometers from Yangambi.

^b The households in this group are located up to 20 kilometers from Yangambi.

Land Quality

Many of the farmers interviewed claimed that the presence of certain tree species provides a good indication of soil fertility. This technique, although crude, has some scientific backing. About 79.7 percent of the household heads attested that forest area to be cleared for farming was selected based on this method.

Once the selection of forest area is made, the traditional head of the clan, in collaboration with an agricultural agent, delimits and divides the area among various farm households within the limits of each household's resources. This practice, instituted by the Colonial Administration to ensure an orderly use of the forest for agricultural purposes, is still observed today. About 81 percent of the households surveyed had their farm fields in the portion of forest preselected for farming in 1982/83. The rest of the households had their farm fields scattered in the forest.

Land Availability and Use

Exact data on land area held by individual clans are not available. All household heads interviewed agreed that land is not a constraint to production. It is abundant and available to any member of the clan. For instance, the Turumbu Rural Community, with a population of 29,532 in 1981, had an area of 4,000 square kilometers. This represents a density of about seven persons per square kilometer. It should be stressed, however, that the area of land that can be cropped is limited by the fact that hand tools have to be coupled with human force to clear the land, an especially energy-consuming activity in the forest zone. The Zairian Basin is clearly a land-surplus, labor-scarce area.

About 80.5 percent of the households exploit the land for two cropping seasons before putting it to fallow. Table 4 shows that 41.9 percent of the households leave their fields to fallow for a period of time ranging from three to six years, while the remaining 58.1 percent of the households put their fields to fallow for at least seven years.

Several measurable changes in tropical soil characteristics occur during the cultivation period, including increased acidity, decreased levels of available plant nutrients,

Table 4—Length of fallow period, by households surveyed, 1982/83

Fallow Period (years)	Percent of Surveyed Households
Less than 4	4.0
4	5.3
5	17.3
6	15.3
7	14.7
8	11.3
9	6.7
10	10.7
More than 10	12.7
Forest*	2.0
Total	100.0

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

* Two percent of the households surveyed had plots in the primary forest.

loss of organic matter, greater compaction, decreased storage of available water, and decreased infiltration capacity. Marked changes in the faunal population and microbiological activity also occur. These detrimental changes undoubtedly influence crop yields increasingly as cultivation is extended beyond one or two cropping cycles or the length of the fallow period is reduced. A minimum fallow period of seven years is necessary to maintain soil fertility in the tropics under a traditional farming system (Greenland and Okigbo 1983).

A minimum fallow period of 10 years was instituted during the Colonial Administration. Most measures initiated during this period were enforced through coercion rather than persuasion (Jurion and Henry 1967). This allegation does not imply, however, that all the measures taken during the period before independence were wrong or unnecessary.

A positive question one should ask is why did a substantial share of farmers shorten the fallow period to less than seven years despite the low population density? One possible explanation may be that reducing the labor input required for clearing by shortening the fallow period could well be an attempt to increase labor productivity where opportunity costs for labor are rising, at least outside the farm sector.

The effects of shortening the fallow period on the intensities of labor and capital use, as well as on the productivities of land, labor, and capital, will be examined subsequently in order to make an economic judgment on farmers' behavior.

Allocation of Cultivated Area among Crops

The cultivated area per household (0.67 hectare) and the cultivated land per man-equivalent in the study area (0.22 hectare) are small by any standards (Table 5). Perreault (1978) found that the cultivated area per household was 0.88 hectare for Yalenge village, 0.94 hectare for Banakanole, and 0.82 hectare for Yambela in the Zairian Basin. All these estimates are smaller than those reported in other regions of the country. Durocher (1983) estimated an average cultivated area of 1.02 hectares per household in Nande Rural Community, Nord-Kivu, and Ntamulyango (1975) re-

Table 5—Cultivated land/man ratio and allocation of cultivated area among crops

Rural Community	Number of Households	Man-Equivalents/ Household	Cultivated Area/ Household	Cultivated Area/Man-Equivalent	Allocation of Area			
					Rice	Maize	Cassava	Plantain
			(hectare)		(percent)			
Turumbu	53	3.88	0.66 (0.51)	0.17	27.61	26.92	33.14	12.32
Yangambi-Kisangani ^a	17	4.24	0.85 (0.77)	0.20	9.13	37.65	32.73	20.49
Weko and Yambaw	17	3.99	0.50 (0.25)	0.13	52.15	21.57	23.29	2.99
Yangambi-Isangi ^b	19	3.46	0.63 (0.35)	0.18	22.19	22.11	42.33	13.37
Mongandjo	53	2.52	0.75 (0.33)	0.30	39.19	9.33	51.48	0.00
Bolikango	25	2.68	0.73 (0.32)	0.27	32.13	11.97	55.90	0.00
Babendja	28	2.37	0.77 (0.34)	0.32	45.50	6.97	47.54	0.00
Bomenge Bomaneh	26	2.38	0.53 (0.33)	0.22	8.75	34.99	54.58	1.68
Study area	132	3.04	0.67 (0.42)	0.22	28.55	21.45	44.73	5.28

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The numbers in parentheses are standard deviations.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

ported an area of 1.48 hectares per household in Bushumba, Sud-Kivu. These figures are not given for comparative purposes. The areas mentioned in these two Kivu regions are in savannah zones. Land preparation requires more energy in the forest zone than in the savannah. In all, the cultivated area per household and cultivated land-man ratio remain small despite the availability of land, both in the Kivu regions and in the Zairian Basin. The key factors affecting the size of cultivated land area and the implications for farm output and labor productivity will be considered later.

Crop area estimates reported in Table 5 show wide intercommunity variability. In Turumbu, cassava claims the largest share of the cultivated area. Rice, maize, and plantain are second, third, and fourth. In Mongandjo, cassava has the largest share of area followed by rice and maize. In Bomaneh, Bomenge Rural Community, cassava occupies the first position; maize, the second; rice, the third; and plantain, the fourth. Overall, cassava covers the most area, followed in decreasing order by rice, maize, and plantain.

Variability in the shares of area devoted to individual crops among villages within the communities reflects both local market conditions and the degree of access to markets in the major centers. The communities with relatively large local markets tend

to allocate more of their cultivated area to cassava, maize, and plantain. The Turumbu villages located along the Yangambi-Kisangani road allocated 90.8 percent of cultivated area to cassava, maize, and plantain, and those along the Yangambi-Isangi road 77.8 percent, with rice claiming the rest. These villages have relatively large local markets (at Yangambi, Lotokila, and Isangi), compared with Weko and Yambaw, which are located in remote forest areas without substantial local markets. They are connected to Yangambi by a very poor road of about 42 kilometers. In Weko and Yambaw, households allocated 52.2 percent of cultivated area to rice alone. Because of its biological nature, rice can be stored and sold over a relatively longer period of time than maize, cassava, and plantain. Therefore, in a remote area without a large local market and poorly connected to major centers, farmers tend to allocate more of their cultivated area to crops that can be stored under farm conditions with limited loss. For this reason, rice has become the major cash crop in poorly connected, remote areas of the Zairian Basin.

This same pattern of land allocation between rice, cassava, and maize also holds for Mongandjo Community. (Production of plantain in Mongandjo is severely constrained by monkeys.) In Bolikango, which is much closer to the major market of Basoko than Babendja, farm households allocated 67.9 percent of the cultivated area to cassava and maize as opposed to 54.5 percent in Babendja. Farmers in Bolikango devoted about 32.1 percent of the cultivated area to rice as opposed to 45.5 percent in Babendja. In Bomaneh, rice is a new crop that was introduced into the farming system in 1981/82. A comparison of rice and other crops does not hold for this community.

Capital Input

As stated earlier, capital inputs available to the peasant farmer include a few hand-held tools and rice and maize seeds produced on-farm.

Quantity of Rice and Maize Seeds Used

The quality of seeds being used in the Zairian Basin has severely degenerated since independence in 1960, because until recently, no seed service existed in the country.⁶

Although data on technically optimal quantities of seeds to be used in a mixed-cropping system are not available, Table 6 indicates that, for the area as a whole, farmers used 59.6 percent for rice and 79.3 percent for maize of the quantity recommended for use in pure cropping by the Institut National d'Etude et de la Recherche Agronomique du Zaïre (INERA 1971).

There is a great deal of divergence among communities and also among villages. For Turumbu Community, the amount of rice and maize seeds used per hectare represents 50.5 percent and 67.0 percent respectively of the amount recommended for pure cropping. In Mongandjo Community, 63.0 percent of rice seeds and more than 100.0 percent of maize seeds were sown. In Bomaneh, rice seeds amounted to 67.3 percent of the quantity recommended for pure stands, and maize seeds, 62.0 percent. On the basis of these data, it seems likely that farmers who planted maize in Mongandjo in 1982/83 used too much maize seed per hectare for mixed stands, rather than too little. For the sample as a whole, 60.6 percent of surveyed households produced rice and 62.1 percent produced maize in 1982/83.

⁶ A new seed project sponsored by the World Bank was established in 1985 and is now operational. It has to be given some time, however, before its impact on the small-farm sector can be assessed.

Table 6—Quantity of seeds used per hectare by households that produce rice and maize, 1982/83

Rural Community	Number of Households Producing		Amount of Seeds Used in Mixed Cropping		Amount of Seeds Used in Mixed Cropping as a Percent of Amount Recommended in Pure Cropping	
	Rice	Maize	Rice	Maize	Rice	Maize
			(kilograms/hectare)		(percent)	
Turumbu	23	38	25.26 (5.26)	20.09 (6.66)	50.52	66.97
Yangambi-Kisangani road ^a	4	14	29.93 (2.22)	22.11 (5.99)	59.86	73.70
Weko and Yambaw	12	16	25.47 (5.27)	21.64 (6.68)	50.94	72.13
Yangambi-Isangi road ^b	7	8	22.23 (4.76)	13.45 (2.88)	44.46	44.83
Mongandjo	53	31	31.50 (7.23)	30.48 (7.26)	63.00	100.16
Bolikango	25	20	32.71 (8.04)	30.44 (7.99)	65.42	101.47
Babendja	28	11	30.41 (6.37)	30.57 (6.07)	60.82	101.90
Bomenge						
Bomaneh	4	13	33.66 (19.99)	18.60 (4.12)	67.32	62.00
Study area	80	82	29.81 (8.12)	23.78 (8.38)	59.62	79.27

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Standard deviations are in parentheses.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

Tools

Because most of the tools used were hand-held, their use was highly correlated with labor time allocated to each crop. Thus, labor shares of individual crops were used as weights to estimate the depreciation of tools allocated to these crops during the 1982/83 crop year. The estimated average depreciation of tools (material capital) per household in the study area as a whole was about Z75.40 for the year (Table 7).⁷

A crop-based comparison shows that 42.5 percent of the tools in the study area were used on rice, followed by 40.4 percent on cassava, 15.1 percent on maize, and 2.0 percent on plantain. Table 7 also indicates much variability between and within communities in the amount spent on capital input (tools) and in allocation among

⁷ The same tools are used in the production of rice, maize, cassava, and plantain. In dollar terms, the cost of tools used per household was about US\$13.11, using the official 1982/83 exchange rate of Z5.75/US\$1.00.

Table 7—Allocation of capital tools among crops, 1982/83

Rural Community	Number of Households	Cost of Capital Tools (Z)	Share of Tools Allocated (percent)			
			Rice	Maize	Cassava	Plantain
Turumbu	53	49.52 (58.80)	41.52	21.98	31.61	4.88
Yangambi-Kisangani road ^a	17	43.33 (57.93)	27.29	29.60	35.06	8.05
Weko and Yambaw	17	47.64 (60.21)	57.47	13.55	26.73	2.25
Yangambi-Isangi road ^b	19	56.74 (60.73)	38.25	23.50	33.43	4.82
Mongandjo	53	98.51 (45.93)	49.30	7.36	43.14	0.20
Bolikango	25	84.12 (51.59)	45.84	7.69	46.29	0.18
Babendja	28	111.36 (36.53)	53.14	7.06	39.58	0.24
Bomenge Bomaneh	26	81.06 (44.36)	18.36	25.62	54.87	1.15
Study area	132	75.40 (55.49)	42.52	15.09	40.40	1.99

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Standard deviations are in parentheses.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

crops. These inter- and intracommunity differences in capital input are also a function of cultivated land area.

Allocation of Seeds and Tools among Crops

Table 8 summarizes the data on capital input (seeds and tools) used per household, by crop. Rice received 48.7 percent of total capital input; cassava, 32.8 percent; maize, 17.2 percent; and plantain, 1.3 percent. Hand tools contributed a much larger share to capital input costs than seeds.

A community comparison indicates that Mongandjo allocated more capital input to farming than Bomaneh and Turumbu. An average household in Mongandjo spent 1.4 times more on capital than an average household in Bomaneh and 1.8 times more than in Turumbu.

In sum, this survey shows that capital input is in short supply in the small-farm sector of Zaire. All farmers interviewed suggested that the lack of an input delivery system, credit facilities, and adequate roads constitute the main constraints to increases in food output and income.

Table 8—Allocation of capital input (seeds and tools) among crops, 1982/83

Rural Community	Number of Households	Total Cost of Capital Input	Share of Total Capital Input Allocated			
			Rice	Maize	Cassava	Plantain
		(Z)				(percent)
Turumbu	53	72.39 — (76.06)	47.25	25.10	23.97	3.68
Yangambi-Kisangani road ^a	17	72.39 (91.00)	39.92	29.45	25.65	4.98
Weko and Yambaw	17	66.45 (76.30)	64.20	12.73	20.48	2.59
Yangambi-Isangi road ^b	19	71.69 (64.11)	40.38	30.94	25.24	3.44
Mongandjo	53	130.90 (55.94)	59.70	7.73	32.46	0.12
Bolikango	25	117.44 (63.19)	57.55	8.85	33.50	0.09
Babendja	28	142.92 (46.47)	61.27	6.90	31.69	0.14
Bomenge						
Bomaneh	26	97.09 (51.15)	20.85	31.32	46.96	0.87
Study area	132	100.74 (68.80)	48.73	17.22	32.76	1.29

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Cassava cuttings and plantain shoots to be planted are collected from previous farm fields by farmers themselves. The time spent on this activity is included in the labor input. Cassava cuttings and plantain shoots are neither bought nor sold in the study area. Tools constitute the only items of capital input used in the production of these two crops in the area. The prices of rice and maize seeds used to compute the value of seeds are reported in Appendix 2. The numbers in parentheses are standard deviations.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

LABOR USE AND ALLOCATION

This chapter presents the calendar of farm operations, the monthly intensity of labor use during the 1982/83 crop year, and the allocation of labor time among crops. In addition, the allocation of labor time between farm and other economic activities performed in the household is discussed.

In this connection, one should recall that small-farm households in the Zairian Basin solely rely on labor provided by household members to carry out economic, domestic, and sociocultural activities. Economic activities are made up of farm and nonfarm activities (such as hunting, fishing, and gathering). Most of these are food-producing activities.

Calendar of Farm Operations and Monthly Intensity of Labor Use

A number of farm-level studies have shown that labor shortages, particularly during peak periods, constitute one of the major constraints to food and agricultural production in most parts of Sub-Saharan Africa (Eicher and Baker 1982; Delgado 1982; Norman 1973b). For this reason the sequences of farm operations as performed by farmers in the area are presented, and attempts are made to verify whether labor shortages are experienced during peak production periods in the Zairian Basin.

The official agricultural calendar of farm operations for the area, based on research conducted at the Institut National pour l'Etude Agronomique du Congo (INEAC)⁸ during the colonial period, is summarized in Table 9. This calendar assumes only one crop season for maize and rice per year, although with the bimodal pattern of precipitation that exists in the area, it is agronomically possible to have one major and one minor crop for both rice and maize per year. From sowing to harvest, three months are required to produce maize and four months for rice. For cassava and plantain, only one crop can be produced a year. The official calendar, however, is not followed by all the farmers in the area.

Table 10, based on Appendix 2, Table 29, presents the agricultural calendar followed in each study community during the 1982/83 crop year. Because crops are planted in mixed stands, farm operations such as land preparation and weeding are simultaneously carried out for all crops. The sowing period, which runs from April to October, is more critical for rice and maize than for cassava and plantain. Harvesting of each crop is performed at the end of the cycle for that crop.

In all, farmers in the study area follow an agricultural calendar that is not strictly the same as the official one. The execution of some farm operations is extended beyond the recommended periods. Does this late execution of some farm operations imply that the demand for labor to carry out various household activities is high and concentrated in time? In other words, is this late execution of farm operations an indication of labor shortages in the area? Or is it merely a tendency among small farmers, partic-

⁸ The institute is now known as the Institut National d'Etude et Recherche Agronomique (INERA).

Table 9—Official calendar of farm operations in the study area

Period When Operations Are to Be Performed	Operations to Be Conducted in the New Farm Field	Operations to be Continued on Last Season's Crops
January-February	Slashing	Weeding and harvesting of cassava and plantain; marketing of rice, maize, cassava, and plantain.
March-April	Burning and clearing of the new plot of land; sowing of rice and maize; planting of cassava and plantain.	Weeding and harvesting of cassava and plantain; marketing of rice, cassava, and plantain.
May-July	Sowing of rice and maize; weeding.	Harvesting and marketing of cassava and plantain.
August-October	Harvesting of rice and maize; weeding of cassava and plantain; selection of plots for the new season.	Harvesting and marketing of cassava and plantain.
November-December	Processing and marketing of rice; weeding of cassava and plantain. The new crop season begins and farmers start clearing the forest.	Harvesting and marketing of cassava. Field will be turned to fallow.

Source: Zaire, Division Régionale de L'Agriculture, "Calendrier Agricole Approuvé pour la Sous/Région de la Tshopo," Kisangani, Zaire, 1980.

Table 10—Farmers' agricultural calendar in the study area, crop year 1982/83

Farm Operation	Turumbu Villages					
	Along Yangambi-Kisangani Road ^a	Weko and Yambaw	Along Yangambi-Isangi Road ^b	Mongandjo		Bomenge
				Bolikongo	Babendja	Bomaneh
Slashing	January-August	January-May	January-May	January-August	January-May	January-May
Burning and clearing	February-May	April-July	May-July	April-October	April-June	April-August
Sowing and planting	April-September	May-September	July-August	May-October	April-August	April-August
Weeding	May-August	July-December	August-October	August-December	August-December	July-December
Harvesting, processing, and marketing	July-December	September-December	October-December	August-December	August-December	August-December

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: This calendar includes only farm operations carried out in the ongoing crop year. Operations related to last crop season performed mainly by female members are weeding of cassava and plantain and marketing of rice and maize during the January-February period. Harvesting and marketing of cassava and plantain continue throughout the year.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

ularly those living in an area where rainfall is relatively well distributed throughout the year, to be flexible about the timing of farm operations?

The survey data summarized in Table 11 show that, for the study area as a whole, the largest amount of labor time allocated to household economic activities in a month was about 88 hours for males and 85 hours for females during the surveyed crop year, while the smallest amount of labor time spent was about 71 hours for males and 23 hours for females. In the humid tropics of Africa, 6 hours a day or 150 hours a month is generally regarded as the maximum a person can productively allocate to labor, either farming or nonfarming; therefore, it seems that, other things being the same, more time could have been devoted to both farming and nonfarming activities in the study area without encountering a labor shortage. The breakdown of labor allocation for each of the communities included in the study is given in Appendix 2, Table 30.

Seasonal Allocation of Labor Between Farming and Nonfarming Tasks

Figure 2, which is based on Appendix 2, Table 30, shows that the intensity of labor use throughout the year exhibits a clear seasonal pattern. Three distinct periods can be delineated for males and four for females. During January-February, the amount of time males allocate to farming increases and that spent on nonfarming activities declines. During the February-April period, the amount of time males allocate to farming is at its highest period. During April-December, the pattern is reversed, with nonfarming activities increasing and farming decreasing. For female members, May-July and September-December are the peak periods for farming activities. During these periods, the level of nonfarming activities performed by females goes down. During the January-May and July-September periods, however, the situation reverses in favor of nonfarming activities.

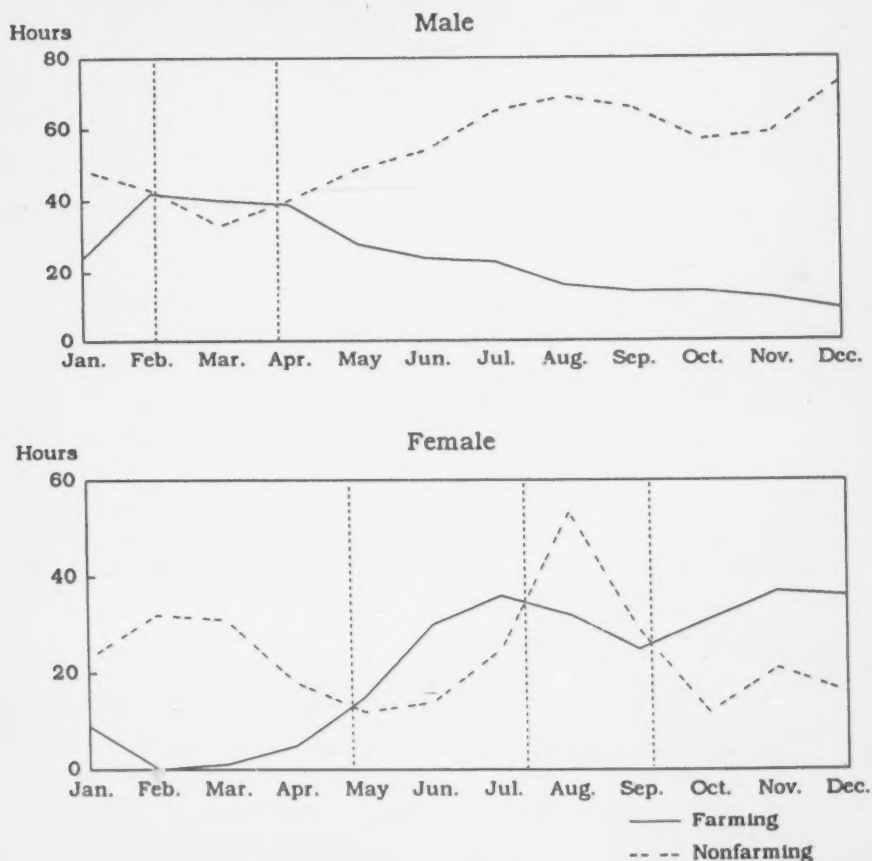
Table 11—Intensity of labor use, by month, 1982/83

Month	Economic Activities (Farming and Non- farming)		Farming		Nonfarming	
	Male	Female	Male	Female	Male	Female
	(hours/month)					
January	73	32	24	9	49	23
February	85	32	42	0	43	32
March	73	32	40	1	33	31
April	79	23	39	5	40	18
May	77	27	28	15	49	12
June	78	44	24	30	54	14
July	88	61	23	36	65	25
August	85	85	16	32	69	53
September	80	54	14	25	66	29
October	71	43	14	31	57	12
November	71	58	12	37	59	21
December	80	52	9	36	73	16

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: These are the average number of hours allocated to farming and nonfarming economic activities by a household member of either gender regardless of age. They should not be regarded as man-hours. Nonfarming activities referred to are hunting, fishing, and gathering.

Figure 2—Intensity of male and female labor use, farming and nonfarming activities, by month, 1982/83



Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

In short, the demand for labor during farming peak periods is met by substituting farming work for nonfarming, rather than by reducing leisure.

Because of the division of labor, the allocation of labor time presents different seasonal patterns for men and women. The time allocated to farming by males is large from January to May, when land preparation is mostly performed. During this period, very little time is devoted to farming by females. The reverse occurs during the period from June to December, when farm operations such as planting, weeding, harvesting, and farm-level processing are performed.

Survey data indicate that high energy-consuming farm operations such as forest slashing, burning, and clearing are almost entirely carried out by men. Less risky, low energy-consuming operations such as planting, weeding, harvesting, processing, and marketing are mainly performed by women, with substantial help from male members. This division of farm operations between men and women is consistent with biological considerations.

The area does not appear to suffer from the seasonal labor shortages that are characteristic of subhumid and semiarid areas of Sub-Saharan Africa. The distribution of rainfall, which is mostly responsible for seasonal labor shortages elsewhere in the Sub-Saharan region is not a factor here. Key factors that affect the allocation of household labor time to farming in the Zairian Basin still have to be identified.

Allocation of Agricultural Labor

Allocation Among Food Crops

Labor input allocated by each member of the household to farm and nonfarm economic activities was recorded four times a week during the one-year field survey. A number of points regarding the allocation of labor among food crops in different communities in the study area can be made based on these data (see Table 12).

In Turumbu and Mongandjo, where rice-growing has a long history, a large share of labor time was allocated to rice during the 1982/83 crop year. Seven times more labor was expended on rice than on maize in Mongandjo and twice as much in Turumbu. Because rice was only recently introduced in Bomaneh, it claimed a relatively small share of the labor allocated to farming, but its labor share was still much larger than that of plantain. A substantial amount of labor time was spent on cassava in all three communities. This allocation of labor to cassava, the main staple food crop in the area, is revealing in terms of concerns about household food security.

Table 12 also shows substantial inter- and intracommunity variability in labor allocation among crops, which has been ascribed earlier to differences in local market conditions and the degree of access to major centers. For the study area as a whole, rice, the major cash crop, claimed slightly more labor than cassava and two-and-a-half times more labor than maize and plantain combined.

Allocation of Labor to Farming

First, regarding the allocation of labor to farming (Table 13), the total labor time spent on economic activities per man-equivalent varied between 449 and 1,292 man-hours per year, with an average of 776 man-hours for the study area as a whole. Since it has already been established that as many as 1,800 man-hours a year can productively be allocated to economic activities per man-equivalent in the humid tropics of Africa, it can be said that the labor input allocated to economic activities in the area is rather low, representing on average 43.1 percent of potential productive labor time. This suggests that the area is still at a low level of economic development and that the economic activities carried out are mainly for subsistence purposes.

Second, the data show that in most villages, farming is second to nonfarming, except in the Turumbu villages along the Yangambi-Isangi road, where productive labor time was almost equally allocated to farming and nonfarming. Overall, the share of farming in total labor time spent on economic activities during the 1982/83 crop year varied between 27.3 and 55.5 percent among villages, giving an average of about 34.9 percent for the area as a whole.

Table 12—Household labor allocations to rice, maize, cassava, and plantain

Rural Community	Number of Households	Labor Allocated to Farming ^a	Rice	Maize	Cassava	Plantain
		(man-hours)			(percent)	
Turumbu	53	844 (469)	41.52	21.98	31.61	4.88
Yangambi-Kisangani road ^b	17	712 (491)	27.29	29.60	35.06	8.05
Weko and Yambaw	17	954 (512)	57.47	13.55	26.73	2.25
Yangambi-Isangi road ^c	19	864 (401)	38.25	23.50	33.43	4.82
Mongandjo	53	954 (351)	49.30	7.36	43.14	0.20
Bolikango	25	1,086 (435)	45.84	7.69	46.29	0.18
Babenga	28	837 (198)	53.14	7.06	39.58	0.22
Bomenge Bomaneh	26	519 (321)	18.36	25.62	54.87	1.15
Study area	132	824 (426)	42.52	15.09	40.40	1.99

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Figures in parentheses are standard deviations.

^a The hours devoted to farming by each member of the household were converted into man-hour equivalents using Collinson's conversion factors reported in Appendix 1.

^b These villages were located up to 22 kilometers from Yangambi.

^c These villages were located up to 20 kilometers from Yangambi.

Third, during the 1982/83 crop year, an average of 271 man-hours per man-equivalent were devoted to agriculture. This limited amount of labor input allocated to farming should not be seen as a consequence of relying on a rainfed agricultural system, where the distribution of rainfall imposes the pattern of labor use and allocation to farming. The distribution of rainfall in the Zairian Basin allows for farming all year round. A comparison with other developing areas indicates that the amount of labor input allocated to farming per man-equivalent in the study area is small even by African standards.

In a review of the literature on labor use in Africa, Eicher and Baker (1982) wrote

Farm level surveys throughout Sub-Saharan Africa have consistently shown that farmers have low annual labor inputs in agricultural production by international standards. Cleave (1974) reviewed 50 micro-level studies in countries of both high and low man-land ratios and found that male adults were working an average of 1,000 hours per year in agricultural production as compared with 2,500 to 3,000 hours per year in Egypt and many Asian countries. Some researchers have reported even fewer hours spent on farming activities, as low as 500 to 600 hours per year (Haswell 1953; Norman 1972).

The survey clearly indicates that farming is not the leading economic activity in the area. Hunting, fishing, and gathering are more important. They claimed about

Table 13—Allocation of household productive labor time between farming and nonfarm economic activities, 1982/83

Rural Community	Number of Households	Average Number of Man-Equivalents/ Household	Labor Allocated to Economic Activities/ Household		Labor Allocated to Farming/ Man-Equivalent		Labor Allocated to Nonfarm Economic Activities/ Man-Equivalent	
			(man-hours)	(percent)	(man-hours)	(percent)	(man-hours)	(percent)
Turumbu	53	3.88 (1.53)	2,279 (1,239)	587	217	36.97	370	63.03
Yangambi-Kisangani road ^a	17	4.24 (1.69)	2,593 (1,326)	612	168	27.45	444	72.55
Weko and Yambaw	17	3.99 (1.49)	2,776 (1,366)	696	239	34.34	457	65.66
Yangambi-Isangi road ^b	19	3.46 (1.38)	1,552 (576)	449	249	55.46	200	44.54
Mongandjo	53	2.52 (0.92)	2,747 (1,250)	1,090	379	34.77	711	65.23
Bolikango	25	2.68 (1.05)	2,395 (928)	894	405	45.30	489	54.70
Babendja	28	2.37 (0.77)	3,062 (1,423)	1,292	353	27.32	939	72.68
Bomenga	26	2.38 (0.73)	1,734 (716)	729	218	29.90	511	70.10
Bomaneh	26	2.38 (0.73)	1,734 (716)	729	218	29.90	511	70.10
Study area	132	3.04	2,359 (1,212)	776	271	34.92	505	65.08

Source: Based on data from Tshikala B. Tshitaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Household members were converted into man-equivalents to take account of age and sex using conversion factors derived from Collinson (1972) (see Appendix 1). Economic activities include farming and nonfarming activities (namely hunting, fishing, and gathering). Figures in parentheses are standard deviations.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

65.08 percent of the labor time allocated to economic activities during the 1982/83 year. A survey conducted in 1974/75 on a small sample of 17 households in Yalibwa, Turumbu Community, revealed that the contribution of hunting, fishing, and gathering activities to household cash income was larger than that of farming. These activities contributed about 54 percent of cash income as opposed to 36 percent from farm products. Handicraft and alcohol production shared 2 percent and 6 percent respectively (Kilumba 1975). Although it can generally be observed that the overall time allocated to economic activities in the study area is low, an assessment of key determinants of labor allocation between activities carried out in the household is beyond the scope of this study, which focuses on farming. A detailed appraisal of household labor use would warrant an entire study by itself.

Determinants of Labor Allocation to Farming

Having established that labor input per man-equivalent is low, a model is devised to identify key factors that affect the allocation of labor to farming in order to assess the implications for labor productivity and to examine policy actions that the government of Zaire should initiate to address this issue. From this exercise, implications for other key parameters such as cultivated land area, farm output, and resource productivity are derived.

Model

As stated earlier, the rural small-farm economy includes farming and nonfarming activities. These two groups of activities compete for the labor time of the household. One can then assume that the amount of labor time allocated to farming per man-equivalent is a function of the domestic terms of trade between farming and nonfarming activities. The amount of capital input available per man-equivalent and the degree of dependency also affect the amount of labor time allocated to farming per man-equivalent.⁹ This formulation also should include a dummy variable for locational and other differences among study communities and an error term.

Formally, one can express this relationship as follows:

$$L/W = f(P_1/P_2, K/W, C/W, D, e), \quad (1)$$

where

L/W = the amount of labor time in man-hours allocated to farming per man-equivalent,

P_1/P_2 = farmgate terms of trade between household agricultural and nonagricultural activities during the preplanting period,

K/W = capital input (in zaires) allocated to farming per man-equivalent,

C/W = degree of dependency expressed as a ratio of the number of household consuming units over

⁹ This chapter deals with resource allocation (of labor) within the small-farm economy. Analysis of the resource flow between smallholder and other components of the national economy, although important, is beyond the scope of the present effort.

the number of man-equivalents,¹⁰

D = dummy for location, and

e = the error term.

It is expected that

$$[\delta(L/W)/\delta(P_1/P_2)] \geq 0; [\delta(L/W)/\delta(K/W)] \geq 0; \text{ and } [\delta(L/W)/\delta(C/W)] \geq 0. \quad (2)$$

This implies that a positive change in the farmgate terms of trade between farm and nonfarm activities, capital input per man-equivalent, and degree of dependency will be associated with a positive change in the amount of labor time allocated to farming per man-equivalent.

Definition of Explanatory Variables

The main ingredients of the expression depicting the amount of labor input allocated to agriculture are capital input and the farmgate price of farm relative to nonfarm commodities produced in the households, and their degree of dependency. In this study, the preplanting farmgate prices for rice, cassava, maize, plantain, and nonfarm products (such as game meat and fish) are taken to be the relevant producer prices that affect labor allocation between household agricultural and nonagricultural activities. For each sampled household, the average preplanting price for the above crops is computed, using each crop's share of labor time allocated to farming as a weight. The price for game meat was considered for Turumbu and Mongandjo Communities, whereas in Bomaneh (Bomenge Community), the price for fish was taken. In the first two communities, hunting is the most important household nonfarm activity, whereas in the last community, fishing is. Appendix 2, Table 31, summarizes the price data.

In this study, the degree of dependency is defined as a ratio of the number of household consuming units over the number of household man-equivalents in order to relate the household food requirements to the size of the household labor force.

Regression Results

A least squares method applied to the survey data gives the regression results summarized in Table 14.

For labor allocated to farming, the regression equation indicates that the fit is fair, and the F-statistic is highly significant at the 1 percent level. The coefficients for both the preplanting farmgate terms of trade between farm and nonfarm activities (P_1/P_2) and the amount of capital input per man-equivalent (K/W) are positive and significantly different from zero, implying that these variables are key determinants of the amount of labor time allocated to farming per man-equivalent (L/W) in the Zairian Basin. The degree of dependency (C/W), introduced in the analysis on the assumption that large household size would also generate pressure to produce more foodcrops, does not explain the amount of labor time allocated to farming. Locational differences among study communities on labor allocation to agriculture are significant.

¹⁰ One consuming unit represents the food consumption of one adult male. The number of household consuming units expresses the household food requirements, whereas the number of man-equivalents, sometimes called working units, represents the available household labor force. The conversion factors proposed by Collinson (1972) to transform household members into consuming units are reported in Appendix 1.

Table 14—Determinants of labor allocated to farming, 1982/83

Explanatory Variables and Important Statistics	Dependent Variable
	Ln(L/W)
Intercept	5.62 (12.42)**
Ln(P ₁ /P ₂)	0.38 (2.70)**
Ln(K/W)	0.28 (4.58)**
Ln(C/W)	0.12 (0.66)
Dummies for location	
D ₁	-0.39 (-2.35)*
D ₃	-0.35 (-1.72)
D ₄	-0.38 (-1.44)
D ₅	-0.26 (-1.36)
D ₆	-1.06** (-4.42)
R ²	0.45
F	14.30
n	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The numbers in parentheses are t-values. Ln(P₁/P₂) is the terms of trade between agricultural and nonagricultural activities, Ln(K/W) is capital input allocated to farming per man-equivalent, and Ln(C/W) is the degree of dependency.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The elasticity estimate of agricultural labor time per man-equivalent with respect to the preplanting farmgate terms of trade is 0.38 and that with respect to capital input per man-equivalent is 0.28. This suggests that a 1.00 percent increase in the preplanting farmgate terms of trade between farming and nonfarming activities will be associated with an increase of about 0.38 percent in labor time allocated to farming per man-equivalent, whereas a 1.00 percent increase in capital input available per man-equivalent will lead to about a 0.28 percent increase in labor time allocated to agriculture per man-equivalent.

These findings suggest that appropriate policy actions to improve both the domestic terms of trade of farm products and the content of capital input (tools, equipments, seeds, fertilizers, and so on) for smallholders need to be considered if farmers are to divert more of their labor time to farming. These policies include infrastructure development and technology policies.

Given the paramount importance of labor in Zaire, an in-depth analysis of this issue is fundamental to understanding how the small-farm sector works and its level of performance. In addition, an assessment of factors that determine the amount of labor allocated to farming will contribute to understanding at least indirectly the workings

of the nonagricultural sector of the rural economy. This alone would clarify the interaction of the two sectors and help the government to formulate appropriate policies. Although the foregoing section of this chapter has identified some key variables affecting the allocation of labor to farming, a detailed appraisal of labor use in the rural economy, with all its related aspects and implications, deserves an entire study, which should logically succeed this piece of work.

RELATIONSHIPS BETWEEN LABOR, CAPITAL, AND CULTIVATED AREA

This chapter estimates the intensities of labor and capital use, identifies their key determinants, establishes the relationship between cultivated area, labor, and capital, and finally relates the above to the observed pattern of labor allocation to farming in the study area. The estimates of the structural parameters derived from this analysis are relevant for policymaking.

Intensity of Labor Use

The estimates of the intensity of labor use by crop reported in Table 15 show that rice is the most labor-consuming crop in the production mix. It is followed by cassava and then maize, while plantain is the most labor saving. Taking the labor per hectare allocated to plantain as a numéraire, one can see that rice requires about 2.95 times more labor than plantain, cassava about 2.21 times, and maize about 1.75 times. For all the crops combined, an average labor input of about 1,230 man-hours per hectare was recorded during the 1982/83 crop year, with a range of 525 man-hours per hectare for plantain and 1,547 man-hours for rice.

This intensity of labor use is high compared with other parts of the developing world, and this becomes even more disturbing in an area characterized by low population density like the Zairian Basin. For example, Lassiter (1982) reported 822 man-hours per hectare in the production of sorghum in Eastern Burkina Faso, and in the Mumbwa area of Zambia, farmers spent 568 man-hours per hectare in the production of maize (Dodge 1977). In Maharashtra State, India, 477 man-hours per hectare were allocated to traditional varieties of sorghum, whereas in Bangladesh, the production of local varieties of aman rice claimed about 1,067 man-hours per hectare (Mellor and Ranade 1986; Hossain 1988).

This high labor intensity is partly explained by high labor requirements for land preparation in the forest zone. This situation is further exacerbated by the use of hand tools and by the hot, humid tropical weather conditions, which increase the difficulty of farming. To these environmental constraints, the amount of labor time allocated to land preparation (slashing, burning, and clearing), which determines the size of cultivated area, seems to be an additional factor explaining high overall labor use per hectare. This is understandable in the sense that if a small amount of labor input is devoted to land preparation, the cultivated area will also be small. Therefore, to produce the highest possible output, relatively more labor input has to be spent on subsequent farm operations, including planting, weeding, harvesting, and farm-level processing. The overall labor use per hectare becomes much higher than it would be otherwise.

Data relating household labor and the size of cultivated area are summarized in Table 16, showing that during 1982/83, about 81.1 percent of the sampled households had a cultivated area that did not exceed 1.0 hectare per household. The rest of the households in the sample, 18.9 percent, had cultivated area greater than 1.00 hectare per household. For the sample as a whole, the average amount of cultivated area per household was 0.67 hectare with a minimum area of 0.05 hectare and a maximum

Table 15—Intensity of labor use, by crop, 1982/83

Crop	Number of Households	Average Area/ Household	Average Labor Input/ Household	Labor Intensity
		(hectare)	(man-hours)	(man-hours/hectare)
Rice	80	0.36	557	1,547
Maize	82	0.19	175	921
Cassava	128	0.29	336	1,159
Plantain	52	0.08	42	525
All crops	132	0.67	824	1,230

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

area of 2.99 hectares per household. If farm households are to be described by the size of cultivated land area, one would say, like Sen (1964), that the study area is made up of very small and small farms. As will be shown later in this chapter, this qualification of farm households based on cultivated area is critical in explaining the patterns of labor and capital use per hectare across farm households.

It is also important to note that the size of cultivated area per household varies enormously relative to the number of man-equivalents per household. The minimum and maximum numbers of man-equivalents per household recorded during the 1982/83 survey were 1.17 and 8.01 respectively with an average of 3.03 man-equivalents per household for the study area as a whole. In addition, the data show that the participation of household members in farming increased with the cultivated land area, but the variation is small relative to variation in cultivated area. This explains the observed pattern of declining labor input per hectare with increasing cultivated land area. Norman (1973b) in his study of farming among the Hausa in northern Nigeria found the same relationship but failed to explore the reasons behind this phenomenon in the Nigerian context. This inverse relationship between per hectare labor input and size of cultivated area has been extensively documented in many Asian and Latin American countries (Booth and Sundhrum 1985).

A close look at Table 16 reveals that the intensity of labor input allocated to land preparation exhibits an inverse relationship to the size of cultivated area. This finding is not anticipated: one would expect the per hectare labor input devoted to land preparation not to be affected by size of cultivated area. One explanation could be a deterioration in the quality of land preparation as larger areas are cultivated.

In addition to the size of cultivated land area, the intensities of labor allocated to land preparation and to subsequent farm operations are also expected to be affected by the length of the fallow period and by the type of crop mix adopted. To capture the effect of the length of the fallow period on the amount of labor time per hectare allocated to land preparation, a dummy variable with a value of one is assigned for a fallow period equal to or greater than seven years; otherwise, zero is assigned. The use of seven years as a benchmark is supported by agricultural research indicating that a minimum fallow period of seven years is necessary to maintain soil fertility in the humid tropics under a traditional farming system (Greenland and Okigbo 1983; Jurion and Henry 1967).

To account for the effects of the crop mix on the intensity of labor input allocated to subsequent farm operations, the share of cassava in cultivated land area is introduced

Table 16—Cultivated area and intensity of labor inputs, 1982/83

Cultivated Area (hectares)	Number of Households (percent)	Average Household Size (man-equivalents)	Area per Household (hectares)	Labor Input for All Farm Operations/ Household	Labor Input for Land Preparation/ Household	Labor Input Other Farm Operations/ Household	Labor Intensity		
							All Farm Operations	Land Preparation	Other Farm Operations
				(man-hours)	(man-hours)	(man-hours/hectare)			
0.25 or less	12.88	2.83	0.19	442.72	181.71	261.01	2,330.11	956.37	1,373.74
0.26-0.50	24.24	3.01	0.38	617.87	279.08	338.79	1,625.97	734.42	891.55
0.51-0.75	29.55	2.97	0.62	805.23	302.07	503.16	1,298.76	487.21	811.55
0.76-1.00	14.39	3.01	0.86	996.50	407.48	589.02	1,158.72	473.81	684.91
More than 1.00	18.94	3.35	1.32	1,247.57	403.85	843.71	945.12	305.95	639.17
Study area	100.00	3.04	0.67	824.42	315.44	508.98	1,230.48	470.81	759.67

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zaïrian Basin, Zaïre, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaïre, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

into the equation. The use of cassava's area share is supported by the fact that small farming in the study area is a cassava-based system, as indicated by the number of households producing this crop. Locational and other differences among study communities are taken into account through a dummy variable. And finally, the intensity of the overall labor input allocated to farming is also related to all these variables.

The regression results depicting these relationships are summarized in Table 17. The analysis shows that locational differences are significant. The regression coefficients for the dummy representing the fallow period display the expected sign, but are not significantly different from zero. This implies that the length of the fallow period does not significantly affect the intensity of labor input allocated to land preparation or to farming as a whole.

The type of crop mix does not explain the intensity of labor input allocated to all the farm operations combined, but it is an important determinant of the intensity of labor input allocated to planting, weeding, harvesting,¹ and farm-level processing. Because the share of cassava is used to express the type of crop mix, this finding indicates that the intensity of labor spent on these farm operations declines as the share of cassava in the cultivated area increases. Specifically, a 1.00 percent increase in the share of cassava leads to a decline of about 0.29 percent in the amount of time per hectare spent on planting, weeding, harvesting, and on-farm processing.

As expected, the coefficient for cultivated area is negative and highly significant in all cases. The elasticities of labor input allocated to land preparation per hectare and to other farm operations with respect to cultivated area are -0.58 and -0.26, respectively, while the estimate of the elasticity of the per hectare labor input allocated to all farm operations combined with respect to the same explanatory variable amounts to -0.42. This implies that a 1.00 percent increase in cultivated area leads to a 0.42 percent decline in intensity of labor input devoted to farming. These findings confirm what has been observed elsewhere in Asia and Latin America.

Intensity of Capital Use

The analysis of capital input data by crops indicates that rice is the most capital-consuming crop in the survey area. By taking the intensity of capital input use for plantain as a numéraire, it can be seen that 1 hectare of rice uses 6.29 times the capital input of plantain, whereas maize uses 3.48 times and cassava 3.42 times more inputs than plantain (Table 18).

The analysis of the same capital input data in relation to the size of cultivated area in Table 19 indicates that the amount of capital (tools and seeds combined) per hectare declines as the size of cultivated area increases. The disaggregation of capital input into tools and seeds gives a different picture. The amount of tools per hectare allocated to farming continues to exhibit an inverse relationship with the size of cultivated area, whereas the amount of seed shows a positive relationship.

In addition to the size of cultivated area, the intensity of capital input is also determined by the type of crop mix adopted. Locational and other differences among study communities are also expected to affect the intensity of capital use. These factors are incorporated in the analysis reported in Table 20. The regression coefficient for the type of crop mix is negative and significantly different from zero at the 1.00 percent level except for the intensity of tool use. The elasticities for the intensity of capital input (tools and seeds) and input of seeds with respect to the type of crop mix are about -0.50 and -1.65 which implies that a 1.00 percent increase in the share of

Table 17—Determinants of the intensity of labor input

Explanatory Variables and Important Statistics	Intensity of Labor Allocated to Farming	Intensity of Labor Allocated to Land Preparation	Intensity of Labor Allocated to Other Farm Operations
Ln (man-hours/hectare)			
Intercept	6.81 (17.17)**	5.35 (51.01)**	6.00 (38.00)**
Ln cultivated area	-0.42 (-7.04)**	-0.58 (-9.14)**	-0.26 (-3.37)**
Ln type of crop mix	-0.07 (-0.67)	...	-0.29 (-2.13)*
Dummy for fallow period	0.0 ^a (0.51)	0.04 (0.48)	...
Dummies for location			
D ₁	0.09 (0.74)	0.65 (4.63)**	-0.64 (-3.88)**
D ₂	0.56 (3.46)**	0.74 (5.02)**	0.23 (1.15)
D ₃	0.40 (3.36)**	0.48 (3.33)**	0.34 (2.29)*
D ₄	0.57 (4.93)**	0.79 (5.64)**	0.46 (3.30)**
D ₅	0.34 (3.17)**	0.38 (2.96)**	0.32 (2.35)*
R ²	0.42	0.48	0.33
F	12.84	18.43	10.24
n	132	132	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 18—Intensity of capital input use by crop

Crop	Number of Households	Average Area/ Household	Average Capital Input/ Household	Intensity of Capital Use
		(hectare)		(Z)
Rice	80	0.36	77.61	215.58
Maize	82	0.19	22.65	119.21
Cassava	128	0.29	33.97	117.14
Plantain	52	0.08	2.74	34.25
All crops	132	0.67	100.74	150.36

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: The capital inputs here are seeds and tools combined.

Table 19—Cultivated area and intensity of capital input

Cultivated Area (hectares)	Number of Households (percent)	Average Household Size (man- equivalents)	Area/ Household (hectares)	Capital Input/Household			Capital Intensity		
				Capital Input (Tools and Seeds)	Tools	Seeds	Capital Input (Tools and Seeds)	Tools	Seeds
				(Z)		(Z/hectare)			
0.25 or less	12.88	2.83	0.19	52.70	49.38	3.32	277.36	259.89	17.47
0.25-0.50	24.24	3.01	0.38	68.44	58.16	10.27	180.08	153.05	27.03
0.51-0.75	29.55	2.97	0.62	104.42	82.71	21.71	168.41	133.40	35.01
0.76-1.00	14.30	3.01	0.86	95.50	70.69	24.81	111.05	82.20	28.85
More than 1.00	18.94	3.35	1.32	173.03	107.35	65.58	131.09	81.33	49.76
Study area	100.00	3.04	0.67	100.74	75.40	25.34	150.36	37.82	112.54

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zaïrian Basin, Zaïre, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaïre, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Table 20—Regression results for determinants of the intensity of capital input

Explanatory Variables and Important Statistics	Intensity of Capital Input Allocated to Farming	Intensity of Tool Use for Farming	Intensity of Seed Use
	Ln (Z/hectare)		
Intercept	4.61 (23.11)**	5.26 (6.41)**	2.24 (14.18)**
Ln cultivated area	-0.42 (-4.32)**	-0.64 (-5.26)**	0.30 (3.82)**
Ln type of crop mix	-0.50 (-2.94)**	-0.17 (-0.82)	-1.65 (-11.80)**
Dummies for location			
D ₁	-1.22 (-5.89) **	-1.34 (-5.20)**	-1.36 (-7.86)**
D ₂	-1.19 (-4.78)**	-1.06 (-3.39)**	-1.50 (-7.79)**
D ₃	-0.73 (-3.76)**	-0.81 (-3.38)**	-1.07 (-6.90)**
D ₄	-0.06 (-0.35)	-0.20 (-0.93)	0.61 (4.55)**
D ₅	0.13 (0.75)	-0.20 (-0.94)	0.24 (1.86)
R ²	0.35	0.39	0.67
F	11.08	12.56	36.95
n	132	132	123

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

cassava in the cultivated area leads to a 0.50 percent decline in the intensity of total capital input and a 1.65 percent decline in the amount of seeds used per hectare.

The coefficient for cultivated area is negative and highly significant in equations where total capital input per hectare and the cost of tools per hectare are used as dependent variables, but positive and highly significant in the equation where the cost of seeds sown per hectare is the dependent variable. The estimates of the elasticities of the intensity of capital input with respect to cultivated area are -0.42 for tools and seeds combined, -0.64 for tools alone, and 0.30 for seeds alone.

These results call for some explanation. Given that the share of tools in capital input is very large (74.9 percent on average for the study area as a whole) and given that these tools are hand held, and thus highly correlated to labor input, the intensity of capital input (tools and seeds combined) would be expected to decline as the size of cultivated area increased, as was the case for intensity of labor input. The observed positive relationship between the intensity of seeds sown and the size of cultivated area, however, suggests that households cultivating a relatively large area of land allocate relatively more land to cash crops (rice and maize) than others. In other words, farmers move from a subsistence to a market-oriented crop mix as the size of cultivated area

increases. A summary of relevant survey data supports this conclusion (Table 21). The share of cultivated area allocated to the cash crops, rice and maize, increases with the size of cultivated land area, whereas the subsistence crops, cassava and plantain, exhibit a declining trend.

An in-depth analysis of this relationship is summarized in Table 22. It shows that the share of cultivated area allocated to cash crops is linearly related not only to the size of cultivated land area, but also to the domestic terms of trade between cash and subsistence crops. The size of cultivated area, as well as the farmgate price of cash crops relative to subsistence crops, are critical variables explaining the change in the share of cultivated area allocated to cash crops by small farmers in the Zairian Basin.

A 1.00 percent increase in the size of cultivated area is associated with a 0.20 percent increase in the share of cultivated area devoted to cash crops, while a 1.00 percent increase in the domestic terms of trade between cash and subsistence crops leads to a 0.12 percent increase in the share of cultivated area allocated to cash crops.

Relationship Between Cultivated Area, Labor, and Capital

The foregoing sections have shown that expansion of cultivated area would reduce the intensities of both labor and capital use, which in turn would help increase the productivity of labor and capital inputs allocated to farming. It should also be stressed that in a situation where land is abundant relative to other resources and yield-increasing technologies are unknown, expansion of cultivated area is the main source of food and agricultural output growth. This depicts most parts of Sub-Saharan Africa and the Zairian Basin in particular, in sharp contrast with many developing areas of Asia and Latin America (Hayami and Ruttan 1985; Paulino 1986). The economic history of Zaire since 1960 suggests that the technological environment facing the small-farm sector is not going to improve in the foreseeable future unless some drastic changes in policy direction are initiated (Tshibaka 1986): therefore, expansion of cultivated area is likely to remain the key determinant of production growth.

Table 21—Cultivated area and change in crop mix

Cultivated Area	Number of Households	Average Household Size	Area/Household	Area Allocated		Share of Area Allocated	
				Cash Crops	Subsistence Crops	Cash Crops	Subsistence Crops
(hectares)	(percent)	(man-equivalents)	(hectares)	(hectare)		(percent)	
0.25 or less	12.88	2.83	0.19	0.07	0.12	37	63
0.26–0.50	24.24	3.01	0.38	0.19	0.19	50	50
0.51–0.75	29.55	2.97	0.62	0.32	0.30	52	48
0.76–1.00	14.39	3.01	0.86	0.41	0.45	48	52
More than 1.00	18.94	3.35	1.32	0.79	0.53	60	40
Study area	100.00	3.04	0.67	0.36	0.31	54	46

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Table 22—Regression results for cultivated area, farmgate prices, and share of cash-crop area

Explanatory Variables and Important Statistics	Dependent Variable Cash-Crop Area Share
Intercept	-0.42 (6.95)**
Cultivated area	0.15 (4.51)**
Farmgate price of cash crops relative to subsistence crops	0.01 (5.05)**
Dummies for location	
D ₁	-0.17 (-2.48)*
D ₃	-0.11 (-1.66)
D ₄	-0.12 (-1.92)
D ₅	-0.04 (-0.69)
R ²	0.46
F	16.87
n	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Because land is abundant and freely accessible to each household in the study area, and given the current state of technology in the area, the expansion of cultivated area depends on the amount of labor time allocated to land preparation and on the amount of capital tools available. This can be expressed as follows:

$$H = f(L_p, K_t, D, e), \quad (3)$$

where

H = the cultivated area in hectares,

L_p = the labor time allocated to land preparation in man-hours,

K_t = capital tools in zaires,

D = a dummy to account for locational and other differences among study villages, and

e = an error term.

The regression analysis was performed using Cobb-Douglas and transcendental functions. Due to serious multicollinearity between labor time allocated to land preparation and capital tools, the original data were transformed assuming a Cobb-Douglas function with constant returns to scale (Koutsoyiannis 1984). An F-test to compare the Cobb-Douglas and transcendental functional forms, derived after this transformation, suggests that the Cobb-Douglas functional form is appropriate. Table 23 displays these regression results. The fit is good and the F-statistic is significant at the 1.0 percent level. Locational differences are, overall, negligible. The coefficient for the ratio of labor to capital is positive and significantly different from zero at the 1.0 percent level.

The estimates of the elasticities of cultivated area with respect to labor time allocated to land preparation and to capital tools are 0.75 and 0.25, respectively. These elasticity estimates suggest that labor time devoted to land preparation is the most important determinant of the size of cultivated area. But one should note that the effects of capital tools used is also significant. More specifically, a 1.00 percent increase in labor time and in capital tools allocated to land preparation will be associated with a 0.75 percent and 0.25 percent increase in cultivated area respectively.

The implications for the intensities of both labor and capital use are obvious. A 1.00 percent increase in labor allocated to land preparation will ultimately lead to a 0.32 percent decline in the intensity of labor input allocated to farming.¹¹

Finally, to reduce the intensity of labor and capital use, the size of cultivated area has to be increased through greater labor time devoted to land preparation. This change in labor use and allocation will have substantial implications for the productivities of both labor and capital, which will be discussed in the next chapter. Moreover, increasing the size of cultivated area assumes that crops to be grown on this incremental area are those that can be easily marketed. The access to market, which reflects the level of infrastructural development, becomes critical. This underscores the need to improve the infrastructure in the area.

¹¹ The intensities of total agricultural labor (L) and capital (K) are related to the amount of labor time allocated to land preparation as follows: $\omega = -\theta\psi$ and $\rho = \mu\psi$, where ω and ρ stand for the elasticities of intensities of labor and capital inputs with respect to labor time allocated to land preparation; $-\theta$ and $-\mu$ stand for the elasticities of the intensities of labor and capital inputs with respect to the size of cultivated area; and finally, ψ is the elasticity of cultivated area with respect to labor time allocated to land preparation.

Table 23—Regression results for the relationship between cultivated area, labor, and input of capital (tools)

Explanatory Variables and Important Statistics	Cultivated Area/ Capital Input (Tools)
	Ln (hectare/Z)
Intercept	-5.66 (-50.44)**
Ln total labor time to land preparation/tools	0.75 (13.60)**
Dummies for location	
D ₁	-0.02 (-0.13)
D ₂	-0.37 (-1.89)
D ₃	-0.07 (-0.38)
D ₄	-0.31 (-1.96)*
D ₅	-0.07 (-0.45)
$\bar{R}^2$	0.69
F	49.16
n	132

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: t-values are in parentheses.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

FARM OUTPUT AND RESOURCE PRODUCTIVITIES IN THE STUDY AREA

Farm Output

Production Function

Under given technological conditions, farm output is viewed as a function of cultivated area, labor, and capital, as well as other variables such as weather. When a cross-section study is carried out in a fairly homogeneous zone, these "other" variables are regarded as given, and the farm output mainly becomes a function of cultivated area, labor, and capital.

This formulation is theoretically adequate, but since land itself is not a constraint to food and agricultural production in the Zairian Basin, the volume of farm output can be regarded as mainly determined by labor and capital inputs. In addition, because fallowing—a natural way of regenerating soil fertility—is the most important feature of the farming system in the area, the effect of the length of fallow on the level of farm output is also examined through a dummy that assumes a value of one for fallows of seven or more years, and zero for those of less than seven years (Greenland and Okigbo 1983). Furthermore, the effects of factors such as locational differences among study communities on the level of farm output are also taken into account through a dummy variable with a value of one for the community of concern and zero otherwise. Formally, this relationship can be expressed as

$$Q = f(L, K, Df, Dl, e), \quad (4)$$

where

Q = the crop output in kilograms,

L = the labor input in man-hours,

K = the capital input in zaires,

Df = the dummy for the length of
the fallow period,

Dl = the dummy for locational dif-
ferences, and

e = the error term.

An important policy variable that is included with this relationship is the period when a new crop—rice—was introduced. Rice was first introduced in Turumbu and Mongandjo during the period 1840-1911, but it was not introduced in Bomaneh until 1981/82. A dummy variable to account for the history of rice in the study area is included in the rice production function, with a value of one assumed for Turumbu and Mongandjo communities and zero for Bomaneh.

For all crops combined, the aggregate output production function includes the type of crop mix adopted as an additional shift variable. As indicated earlier, the share of the subsistence crop, cassava, in cultivated area also expresses this variable in the production function analysis.

Regression Results

Input/output data from the 1982/83 survey were regressed against the model developed above. Cobb-Douglas and transcendental functions were estimated. Due to serious multicollinearity between labor and capital inputs, the original data were transformed assuming a constant returns to scale Cobb-Douglas production function. An F-test comparing the Cobb-Douglas and transcendental forms showed the Cobb-Douglas to be a more appropriate transformation (Koutsoyiannis 1984).

For crops other than rice, the transformation in which the average product of capital (Q/K) was regressed against the labor/capital ratio (L/K) produced the most robust regression results. For rice, however, the transformation having the average product of labor (Q/L) and capital/labor ratio (K/L) as the main argument turned out to be best. The econometric reason for this is not immediately obvious. The most robust equation for either crop is given in Table 24. It is striking to see that in either case, however, the estimates of output elasticities remain the same (see Appendix 2, Table 32).

The analysis shows that capital relative to labor is the most important factor affecting the production of rice in the area, while labor input has a stronger impact on maize than capital. For cassava and plantain, labor is the overriding input. For all crops combined, the analysis suggests that labor is the main determinant of the farm output level. The labor share of the aggregate crop output is about 78 percent, whereas that of capital input amounts to about 22 percent. When all is said and done, however, it should be kept in mind that, even in this predominantly subsistence sector, the effects of capital cannot be ignored, although they are small relative to those of labor.

The analysis also indicates that the type of crop mix adopted is an important shift parameter of the overall household crop output, but locational differences among study communities cannot be ignored, and the length of the fallow period does not seem to affect the level of farm output. Finally, the date when an innovation—rice—is introduced in a community is an important variable. The analysis of rice input/output data indirectly suggests that delaying the introduction of improved inputs and techniques in a given area could seriously hinder agriculture in that area. Time plays a critical role in the process of technological change.

Resource Productivities

Average Products of Inputs

At the outset, one should note that the farm output per hectare (all crops combined), achieved under a cassava-based, mixed-crop, traditional farming system in the Zairian Basin, is quite substantial (Table 25).

The average products of labor and capital (expressed in cereal equivalents) and their values are higher in the production of cassava and plantain than in maize and rice, suggesting that cassava and plantain are more productive and profitable than maize and rice in the area. Furthermore, it is important to observe that the productivities of land, labor, and capital vary greatly across commodities within this relatively homogeneous area. This result is confirmed by a number of other studies conducted elsewhere in Sub-Saharan Africa. In the rain forest of Côte d'Ivoire, den Tuinder (1978) found that the returns to labor across major crops varied by a factor of one to five, and the

Table 24—Regression results for food crop production functions

Explanatory Variables and Important Statistics	Crop/Dependent Variable				
	Rice Ln Q/L	Maize Ln Q/K	Cassava Ln Q/K	Plantain Ln Q/K	All Crops Ln Q/K
Intercept	-1.06 (-2.14)*	0.60 (1.96)	2.72 (17.63)**	2.92 (12.13)**	0.93 (4.31)**
Ln L/K	...	0.63 (4.42)**	0.98 (16.11)**	0.85 (9.18)**	0.78 (11.24)**
Ln K/L	0.87 (5.38)**	...	...	...	...
Dr	2.14 (5.06)**	...	...	...	...
Df	0.21 (0.99)	-0.22 (-1.03)	0.04 (0.34)	0.12 (0.61)	0.05 (0.44)
S	...	...	...	...	0.83 (2.57)**
Dummies for location					
D ₁	0.08 (0.18)	0.73 (2.13)*	-0.58 (-2.96)**	0.41 (1.58)	0.11 (0.54)
D ₂	1.09 (3.39)**	-0.16 (-0.41)	-1.17 (-5.60)**	0.27 (0.66)	-0.78 (-3.34)**
D ₃	0.58 (1.64)	-0.07 (-0.17)	-0.24 (-1.22)	-0.10 (-0.38)	-0.25 (-1.31)
D ₄	0.01 (0.05)	-0.52 (-1.55)	0.65 (3.60)**	...	0.53 (3.06)
D ₅	...	-0.09 (-0.25)	0.61 (3.91)**	...	0.34 (2.22)*
R ²	0.41	0.45	0.75	0.74	0.63
F	8.81	8.71	54.43	29.17	28.14
n	80	82	128	52	132
Elasticities with respect to					
L	0.13	0.63	0.98	0.85	0.78
K	0.87	0.37	0.02	0.15	0.22

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Dr is the dummy for the date of introduction of rice in the study communities, Df the dummy for the length of the fallow period, and S the cassava share of the cultivated area to represent the type of crop mix. Output for all crops combined is expressed in kilograms of cereal-equivalents using the following conversion factors: 1.00 for maize-grains, 0.60 for paddy rice, 0.303 for cassava, and 0.220 for plantain; t-values are in parentheses. Because rice, compared with other crops, requires relatively more capital than labor, the transformation of data was performed using labor as a deflator (L). For other crops and all crops combined, which happen to require more labor than capital compared with rice, the transformation was made using capital as a deflator (K). The use of capital as a deflator in the rice equation and labor in other crop equations give the regression coefficients for the labor/capital ratio (Ln L/K) in the rice equation and capital/labor ratios (Ln K/L) in all other equations that are not statistically different from zero except in the case of maize. All the estimates of the critical parameters, for example, the elasticities, are the same regardless of the deflator used (see Appendix 2, Table 32).

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 25—Resource use and productivities in the study area

Item	Rice	Maize	Cassava	Plantain	All Crops
Resource use and output					
Distribution of crops among households	80	82	128	52	132
Cultivated area (hectare)	0.36	0.19	0.29	0.08	0.67
Labor (man-hours)	557	175	336	42	824
Capital (Z)	77.61	22.65	33.97	2.74	100.74
Output (kilograms of cereal-equivalents)	324.66	213.07	2,225.14	133.20	2,539.31
Share of each crop in total output (percent)	7.75	5.21	84.97	2.07	100.00
Average products of resources and their values					
Crop yield (kilograms of cereal-equivalents/hectare)	901.83	1,121.42	7,672.90	1,665.00	3,790.00
Value of crop yield (Z/hectare)	5,576.32	11,875.84	24,563.41	9,762.95	11,714.55
Average product of labor (kilograms of cereal-equivalents/man-hour)	0.58	1.22	6.62	3.17	3.08
Value of average product of labor (Z/man-hour)	3.60	12.92	21.19	18.58	9.52
Average product of capital (kilograms of cereal-equivalents/Z)	4.18	9.41	65.50	48.61	25.21
Value of average product of capital (Zaires/Z)	25.85	99.65	209.69	285.03	98.30
Marginal products of resources and their values					
Marginal product of labor (kilograms of cereal-equivalents/man-hour)	0.08	0.77	6.49	2.69	2.40
Value of marginal product of labor (Z/man-hour)	0.50	8.15	20.76	15.76	9.74
Marginal product of capital (kilograms of cereal-equivalents/Z)	3.64	3.48	1.31	7.29	5.55
Value of marginal product of capital (Zaires/Z)	22.49	36.85	4.19	42.72	35.57

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: The outputs of individual crops are converted into cereal-equivalents using the following conversion factors: 1.00 for maize-grains, 0.60 for paddy rice, 0.303 for cassava, and 0.220 for plantain. The estimates for individual crops and for all the crops combined are based on weighted sample sizes. In addition, since most maize output in the study area is used for the production of a local beverage, the value of average product of maize in production of the drink, which is about Z10.59 per kilogram of maize, is used as the "implicit" price of maize. The average product of maize in the production of local beverage as about 1.05 liter per kilogram of maize, and the average price of one liter of this drink was Z10.09 during the survey. Farmgate prices used to compute values of marginal and average products of resources are reported in Appendix 2, Table 31. The marginal products of resources are computed by multiplying the average products of resources with the elasticities of output.

returns to land even more. The great variability in resource productivity across areas and within areas among crops in the Sub-Saharan region could be ascribed to differences in soil types, ecology, agricultural practices, biological nature of individual crops, physical and human capital, and so forth.

Labor productivity in the Zairian Basin is lower than in other parts of Sub-Saharan Africa, particularly in the production of cereals (Mellor, Delgado, and Blackie 1987; Mellor and Ranade 1986; Dodge 1977; Massell and Johnson 1968). This study attempts to answer the basic question of whether the observed level of labor productivity can be increased given the current state of technology and resource endowment in the area.

Increasing Labor Productivity

Smallholder agriculture in the Zairian Basin has four basic characteristics: low labor input per man-equivalent, a low capital-labor ratio, a high labor share of output, and a low average product of labor. This suggests that the small-farm sector in the Zairian Basin is still at a low stage of development (Hayami and Ruttan 1985).

The current debate in Sub-Saharan Africa is how to increase the productivity of labor and consequently agricultural income. Conceptually, increasing labor productivity involves two groups of related actions. The first group concerns actions that will prompt movement along the production curve to a point where the value of the marginal product of labor is equal to the implicit wage rate. At that level, the average product of labor maximizes the returns to labor input. The second group of actions includes those that lead to an upward shift in the farm production curve. In sum, the first group of actions takes an improvement approach, while the second defines a transformation. A combination of these actions results in a substantial increase in the labor productivity (average product) of the farm sector.

This section examines whether a movement along the production curve, given the current resource base in the study area, could result in increased labor productivity, and if so what actions need to be considered in order to achieve this goal. Put differently, it analyzes, on the basis of survey data, the effects of an increased allocation of labor to farming on the productivity of labor.

Grouping the sample households on the basis of cultivated land area, as reported in Table 26, reveals that substantial increases in labor time allocated to farming are possible and, if accomplished, would ultimately result in a tremendous increase in labor productivity. Conservatively, it is possible for all households in the area to achieve, with the current resource base, an average level of labor productivity of about 3.88 kilograms of cereal-equivalents per man-hour. This represents an increase of about 26 percent over the labor productivity of 3.08 kilograms of cereal-equivalents per man-hour attained in the study area as a whole.

This is not sufficiently brought out in most studies simply because researchers tend to estimate resource productivities computed at the mean values of the inputs for the study sample as a whole. This procedure unwittingly masks the fact that a disaggregation of the study sample indicates that a large part of the study households could be productive at a level that is compatible with their current resource base if appropriate actions were taken. This leads to the conclusion that by increasing the time spent performing land preparation and other farm operations, productivity would improve. As Chapter 5 has shown, increasing the labor allocated to farming requires that both the domestic terms of trade of farm products and the content of capital input in the farm sector be improved.

Finally, it needs to be stressed that in increasing capital content not only should the availability of tools and seeds be increased through appropriate distribution, marketing, and credit policies, but also the nature of these capital inputs should be changed. High-yielding seeds in conjunction with fertilizers and pesticides should be provided—particularly for rice and maize production. Introducing these technological changes into the production process will improve the productivity of labor and other primary inputs (Dodge 1977; Mellor and Ranade 1986; Hossain 1988).

Table 26—Allocation and productivity of labor, 1982/83

Cultivated Area (hectare)	Number of Households (percent)	Available Labor Force per Household (man-equivalents)	Average Area per Household (hectares)	Labor Input to Farming		Volume of Output		Intensity of Labor Use (man-hours/hectare)	Labor Productivity (kilograms of cereal-equivalents/man-hour)
				Per Household	Per Man-Equivalent	Per Household	Per Man-Equivalent		
				(man-hours)		(kilograms of cereal-equivalents)			
0.25 or less	12.88	2.83	0.19	442.72	156.44	726.06	256.56	2,330.11	1.64
0.26-0.50	24.24	3.01	0.38	617.87	205.27	1,278.99	424.91	1,625.97	2.07
0.51-0.75	29.55	2.97	0.62	805.23	271.12	2,455.95	826.92	1,298.76	3.05
0.76-1.00	14.39	3.01	0.86	996.50	331.06	3,537.58	1,175.28	1,158.72	3.55
More than 1.00	18.94	3.35	1.32	1,247.56	372.41	4,840.53	1,444.93	945.12	3.88
Study area	100.00	3.04	0.67	824.42	271.19	2,539.21	835.27	1,230.48	3.08

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

POLICY IMPLICATIONS AND CONCLUSIONS

Resource Use and Allocation

The survey indicates that, despite ready availability of land, the cultivated area per household and the cultivated land-man ratio remain small, largely because the amount of labor time allocated to farming is limited and capital inputs are scarce. The elasticity of cultivated area with respect to labor allocated to land preparation was estimated at about 0.75 and that with respect to input of capital tools at 0.25, which suggests that the expansion of cultivated area is primarily determined by the labor time spent on land preparation and secondarily by the amount of capital tools.

According to this study, only 271 man-hours per man-equivalent were spent on farming in this zone during 1982/83—a much smaller time than has been recorded elsewhere in Sub-Saharan Africa. Cleave (1974) reported an average of 1,000 man-hours and Haswell (1953) and Norman (1972) mention 500 to 600 man-hours per man-equivalent per year. Farming's share of productive labor time was only about 35 percent; the remaining 65 percent was spent on activities such as hunting, fishing, and gathering.

The finding that a 1.00 percent increase in the preplanting farmgate price of farm products relative to nonfarm goods was associated with a 0.38 percent increase in the amount of labor allocated to farming indicates that farmers are responsive to price increases, but they perceive that other activities are more productive than farming. Another critical factor affecting the amount of labor devoted to farming in the study area is the availability of capital inputs at the household level. A 1.00 percent increase in the amount of capital input per man-equivalent allocated to farming resulted in a 0.28 percent increase in the amount of labor input devoted to farming.

Although time spent on agricultural labor is low for small farmers in the Zairian Basin, the amount of labor required to farm a hectare of land is high. For all crops combined (rice, maize, cassava, and plantain), an average labor input of about 1,230 man-hours per hectare was recorded during the 1982/83 crop year. Labor intensity ranged from 525 man-hours per hectare for plantain to 1,547 man-hours for rice. This per hectare labor use is high compared with other parts of Sub-Saharan Africa and Asia. For example, 822 man-hours of labor per hectare of sorghum were recorded in Eastern Burkina Faso and 568 man-hours per hectare of maize in the Mumbwa area of Zambia. The production of local varieties of sorghum in Maharashtra State, India, required 477 man-hours per hectare, and that of local varieties of aman rice in Bangladesh 1,067 man-hours.

The high labor input per hectare in the Zairian Basin is mostly explained by the large amount of energy consumed in land preparation with hand tools in this rain-forest area. The tropical climate saps farmers' energy and contributes to the drudgery of farming. To these environmental constraints, the relatively small amount of labor allocated to land preparation constitutes an additional hindrance. The intensity of labor use per hectare was found to be negatively related to the size of cultivated area. A 1.00 percent decrease in cultivated area is associated with a 0.42 percent increase in the per hectare labor use. Because so little land is prepared, the intensity of labor use per hectare tends to be higher. Increasing labor allocated to land preparation would

help reduce the intensity of labor use per hectare. A 1.00 percent increase in labor allocated to land preparation is associated with a 0.75 percent increase in cultivated area, which, in turn, translates into a 0.32 percent decline in the amount of labor input per hectare.

Resource Productivities

Considering the productivities of resources—that is, the average products of inputs and their values—the study shows that cassava and plantain are the most productive and profitable crops in the area. The expansion of cassava and plantain output has to be tied to the development of livestock and related industries. Without this vertical integration, the long-term prospects are not encouraging, because demand for these crops (for human consumption) tends to decline as incomes rise. Rice and maize, the two cereals produced in the area, have not been very productive, although agronomic studies conducted in the area suggest that the production of improved varieties could yield at least 2,500 and 3,000 kilograms per hectare, respectively, compared with about 900 and 1,100 kilograms per hectare at present.

Low productivity of labor in the study area, particularly in the production of cereals, is indicative of the small-farm sector in Zaire. And this is one of the key factors underlying the decrease in per capita food output that has characterized the country for the last two decades. To reverse the situation, substantial efforts to enhance the productivity of labor input have to be initiated.

Conclusions

To increase the productivity of agricultural labor in the Zairian Basin, the study suggests that efforts to stimulate farmers to allocate more labor to farming should be initiated by the Zairian Government. Since allocation of labor to farming is mostly determined by the domestic terms of trade between farm and nonfarm products and by the content of capital input available to farmers, two sets of related policy actions need to be considered.

First, the public sector should assume a larger role in efforts to integrate this remote area into the mainstream of the national economy through investment in infrastructural development such as roads and transportation systems. This integration will enhance the terms of trade of farming in the area.

Second, steps to promote the capital market and to increase farmers' access to this market through a set of policies including credit and pricing policies must be taken. Specifically, measures to establish a distribution and marketing system for tools, equipment, and seeds need to be examined in the short-to-medium term.

Furthermore, with respect to the introduction of improved rice seeds, investments in biological and chemical technologies offer opportunities to improve the productivity of labor and other primary inputs, particularly in the production of cereal crops.

Each of these policy actions is indispensable for getting agriculture moving in the area. The cost of these policy actions is important, but whether these expenditures have to be made is not a debatable issue. The Zairian Basin represents almost 40 percent of the total land mass. Investments in this region are a must if a stimulating economic environment is to be created despite the region's sparse population. The development of the farm sector alone (food and nonfood crops) will not cover the costs, but because of these investments, other economic activities will develop.

Perhaps the most important open question is that of sequencing and timing of investments in view of limited government and private resources. A detailed analysis of this issue is a necessary and useful complement to this study. Based on the findings here, however, the first actions should include maintenance of the existing road network, the development of an input delivery system for tools, equipment, and seeds, and the provision of credit. Finally, it should be stressed that the rain forest zone of Sub-Saharan Africa is more suited to tree crops than to annual food crops. Logically, therefore, the appropriate smallholder agriculture to promote in the Zairian Basin in the long run is a tree crop production system, with farm households relying largely on purchased food. But, in the short and medium terms, smallholders in the area will continue to be primarily food-producing.

It is hoped that the findings of this study will provide a guideline for policymakers to follow in designing policies to enhance the production of food crops in the short and medium terms, as well as the production of tree crops by smallholders in the long run. Although this study is concerned with a rather small part of rural Zaire, both the findings and the policy implications should have wider relevance for Zaire as a whole.

APPENDIX 1: SOME METHODOLOGICAL NOTES

Statistical Method Used in Allocating Cultivated Area Among Mixed Crops

The method formulated here was proposed by the Institut National des Statistiques et d'Etudes Economiques de France in the book entitled *La Statistique Agricole dans les Pays en voie de Développement*, as presented in Kaseko (1976).

The symbols are defined as follows:

- A and B = two crops in mixed stands,
- d_A and d_B = densities of these crops in a pure cropping system,
- d'_A and d'_B = densities of the same crops when they are mixed,
- T_A and T_B = areas effectively occupied by these crops, and
- T = total area.

Let

$$a_A = d'_A/d_A \text{ and } a_B = d'_B/d_B.$$

It is accepted that the areas occupied by A and B are proportionate to a_A and a_B respectively. It is also accepted that

$$T_A/a_A = T_B/a_B, \text{ and } T_A + T_B = T.$$

Thus,

$$T_A = T(a_A/a_A + a_B), \text{ and } T_B = T(a_B/a_A + a_B).$$

This can be generalized to include n crops in mixed stands as follows:

$$T_i = c_i T,$$

where

$$c_i = A_i / \sum_{i=1}^n a_i.$$

The coefficient, c_i , is referred to as the part of the cultivated land effectively occupied by crop i.

For the purpose of the study, pure crop densities were computed using the following crop spacings proposed by Institut National d'Etude et de la Recherche Agronomique (1971):

0.30 meter $\times$ 0.20 meter for rice,
0.75 meter $\times$ 0.50 meter for maize,
1.00 meter $\times$ 1.00 meter for cassava, and
4.00 meters $\times$ 4.00 meters for plantain.

Mixed crop densities were estimated directly from yield plots.

Yield Plot Method

Yield plots of 9 square meters each were selected for rice, a high-density crop. For maize and cassava, plots of 16 square meters and 25 square meters each were considered. Because the number of plantains in the fields was limited, a complete count was performed. The operation was spread over a long period of time during the survey for cassava and plantain, slow-maturing crops.

The yield plot method tends to overestimate actual crop yields, particularly when the fields are heterogeneous and contain mixed crops (Tollens 1975; Poate and Casley 1985). To reduce the level of this error, five plots were delimited in each household field. The number of plants in these five plots were counted. Due to variation in soil fertility, crop density, and a number of other factors, the pattern of crop yield variation within a field approximates a clustered rather than a random distribution. Therefore, at harvest time, each field was divided into four clusters. The number of plants counted in the five yield plots were randomly harvested all over each cluster; and the crop yield for the field was then derived.

This method provides an estimate of the biological rather than the economic yield because it does not account for crop losses. Nevertheless, the estimates of biological crop yields are still relevant for policy analysis. The estimation of crop losses that occur between harvest and the disposition of the crop constitutes an important research topic on its own merits.

Collinson's Conversion Factors for Man-Equivalents

In his book entitled *Farm Management in Peasant Agriculture, A Handbook for Rural Development Planning in Africa*, Collinson (1972) proposes a set of conversion factors that take age and sex into account in transforming farm household size into man-equivalents. Spencer (1972) in his rice study conducted in Sierra Leone proposes a different set of conversion factors. Norman (1973b) in his study of peasant agriculture among the Hausa in northern Nigeria suggests yet another set of conversion factors. After a critical examination of these three sets of conversion factors in the context of small farming in the Zairian Basin, Collinson's conversion factors were adopted (see Table 27). The breakdown of man-equivalents per household for the entire study area is given in Table 28.

Table 27—Collinson's conversion factors for man-equivalents

Age Group (years)	Male	Female
Less than 10	0.00	0.00
10-14	0.25	0.25
15-19	0.67	0.50
20-55	1.00	0.67
More than 55	0.67	0.50

Source: M. P. Collinson, *Farm Management in Peasant Agriculture, a Handbook for Rural Development Planning in Africa* (New York: Praeger, 1972).

Table 28—Number of man-equivalents per household in the study area

Rural Community	Number of Households	Males	Females	Total
(man-equivalents/household)				
Turumbu	53	2.19 (1.12)	1.69 (0.73)	3.88 (1.53)
Yangambi-Kisangani road ^a	17	2.47 (1.11)	1.77 (0.88)	4.24 (1.69)
Weko and Yambaw	17	2.12 (1.23)	1.87 (0.73)	3.99 (1.49)
Yangambi-Isangi road ^b	19	1.99 (1.02)	1.46 (0.56)	3.45 (1.38)
Mongandjo	53	1.29 (0.59)	1.23 (0.59)	2.52 (0.92)
Bolikango	25	1.35 (0.68)	1.33 (0.69)	2.68 (1.05)
Babendja	28	1.24 (0.50)	1.13 (0.48)	2.37 (0.77)
Bomenge	26	1.28 (0.41)	1.10 (0.56)	2.38 (1.73)
Bomaneh				
Study area	132	1.65 (0.41)	1.39 (0.69)	3.04 (1.36)

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: Figures in parentheses are standard deviations. Collinson's conversion factors reported in Table 27 are used to compute man-equivalents.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

APPENDIX 2: SUPPLEMENTARY TABLES

Table 29—Agricultural calendar for study villages, 1982/83

Location/Farm Operation	J	F	M	A	M	J	J	A	S	O	N	D
Yangambi-Kisangani road^a												
Slashing	•	•	•	•	•	•	•	•				
Burning and clearing		•	•	•	•	•	•	•	•			
Planting				•	•	•	•	•	•			
Weeding					•	•	•	•	•	•	•	•
Harvesting, processing, and marketing							•	•	•	•	•	•
Weko and Yambaw												
Slashing	•	•	•	•	•	•	•	•	•			
Burning and clearing				•	•	•	•	•	•			
Planting					•	•	•	•	•	•	•	•
Weeding							•	•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Yangambi-Isangi road^b												
Slashing	•	•	•	•	•	•	•	•	•			
Burning and clearing					•	•	•	•	•	•	•	•
Planting							•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Bolikango												
Slashing	•	•	•	•	•	•	•	•	•	•	•	•
Burning and clearing				•	•	•	•	•	•	•	•	•
Planting					•	•	•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Babendja												
Slashing	•	•	•	•	•	•	•	•	•	•	•	•
Burning and clearing				•	•	•	•	•	•	•	•	•
Planting				•	•	•	•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing, and marketing								•	•	•	•	•
Bomaneh												
Slashing	•	•	•	•	•	•	•	•	•	•	•	•
Burning and clearing				•	•	•	•	•	•	•	•	•
Planting				•	•	•	•	•	•	•	•	•
Weeding								•	•	•	•	•
Harvesting, processing and marketing								•	•	•	•	•

Notes: This calendar includes only farm operations carried out in the ongoing crop year. Operations related to last crop season performed mainly by female members are weeding of cassava and plantain, and marketing of rice and maize during the January-February period. Harvesting and marketing of cassava and plantain continue throughout the year.

^a These villages were located up to 22 kilometers from Yangambi.

^b These villages were located up to 20 kilometers from Yangambi.

Table 30—Monthly intensity of labor allocated to farm and nonfarm activities per member household, 1982/83

Month	Turumbu Villages										Average for Study Area			
	Along Yangambi-Kisangani Road		Weko and Yambaw		Along Yangambi-Isangani Road		Boilikango		Babendja		Bomange Bomaneh		Non-Farming	
	Non-farming		Farming		Non-farming		Farming		Non-farming		Farming		Farming	
	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming	Farming	Non-farming
(number of hours/month)														
Males														
January	20	52	12	49	17	29	28	69	44	61	20	38	24	49
February	23	54	43	58	40	25	51	50	55	36	37	34	42	43
March	25	27	42	51	46	26	37	40	55	29	35	29	40	33
April	24	55	28	60	37	27	66	28	55	45	23	29	39	40
May	18	70	29	75	24	41	59	20	15	81	24	26	28	49
June	17	71	24	67	25	46	46	27	21	114	12	22	24	54
July	21	74	31	74	31	31	45	36	6	180	6	23	23	65
August	14	75	31	63	21	29	22	53	7	200	3	25	16	69
September	18	53	14	55	15	27	16	58	7	186	14	38	14	66
October	20	60	5	52	23	26	9	67	14	109	12	37	14	57
November	17	57	7	37	26	23	9	77	12	152	3	27	12	59
December	14	76	8	70	11	37	3	84	18	155	1	39	9	73
Females														
January	18	17	27	17	15	12	3	45	0	13	9	23	9	23
February	0	41	0	18	0	28	0	49	0	28	1	25	0	32
March	1	15	0	32	0	9	1	67	0	34	3	24	1	31
April	1	22	5	18	3	11	1	19	8	34	10	11	5	18
May	4	8	23	10	6	11	1	5	6	36	56	8	15	12
June	9	7	25	10	28	8	31	6	49	55	24	7	30	14
July	11	25	49	14	37	11	76	25	30	73	6	11	36	25
August	14	47	44	50	22	31	74	36	22	197	7	7	32	53
September	11	13	31	12	23	10	38	22	28	140	15	3	25	29
October	24	6	22	6	41	6	25	23	55	26	12	4	31	12
November	28	9	37	3	55	4	58	29	39	90	6	4	37	21
December	25	13	39	2	26	3	53	25	55	61	4	2	36	16

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zaïrian Basin, Zaïre, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaïre, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Note: These are hours allocated to farming and nonfarming by average household member of either gender regardless of age. They should not be regarded as man-hours. Nonfarm activities refer to hunting, fishing, and gathering.

Table 31—Preplanting farmgate prices in the study area, 1982/83

Rural Community/ Farm Number	Villages	Rice Paddy	Maize	Cassava (Raw)	Plantain Bunch	All Four Crops ^a	Game Meat
(Z/kilogram)							
Turumbu							
2-16	Yalungu and Yaselia	3.65	1.10	0.59	0.78	0.87	13.04
17-23	Bosukulu	3.98	1.26	0.64	0.79	0.95	15.47
24-29	Yaondolo II and Yandimbila II	5.00	1.14	0.65	0.71	1.03	13.81
30-35	Yalolia II	5.00	1.18	0.73	0.64	1.10	15.86
36-48	Weko	3.16	1.01	0.29	0.53	0.57	18.23
49-61	Yambaw	1.78	1.04	0.25	0.40	0.43	14.19
62-76	Yakwondi and Obiloto	3.73	1.20	0.75	1.47	0.73	9.48
77-82	Lilanda	3.99	1.40	1.46	1.75	1.66	8.31
83-85	Yambeke and Yaisowa	2.91	1.24	1.26	1.64	1.39	7.52
Mongandjo							
86-105	Bolikango I and II	3.88	1.43	1.01	1.08	1.27	5.28
106-115	Bomboma	3.45	1.43	1.27	1.43	1.45	14.00 ^b
116-137	Bolima and Bokangela	2.75	1.38	1.33	2.25	1.45	13.06
138-145	Bokobangolo and Bodjonga	2.50	1.00	1.00	1.35	1.11	9.81
Bomenge							
146-175	Bomaneh	5.53	2.03	1.45	1.8	1.82	5.89 ^b
Study area							
2-195		3.67	1.27	0.91	1.19	1.12	11.71

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

^a The share of each crop in total labor input allocated to farming was used as a weight for the weighted average farmgate price for the period of September 1982 to March 1983. During the period between September and March, most of the land preparation is performed.

^b The price of fish is given instead of meat.

Table 32—Regression results for food crop production functions using capital as a deflator for rice and labor for other crops

Explanatory Variables and Important Statistics	Crop/Dependent Variable				
	Rice Ln Q/K	Maize Ln Q/L	Cassava Ln Q/L	Plantain Ln Q/L	All Crops Ln Q/L
Intercept	-1.06 (-2.14)*	0.60 (1.96)	2.72 (7.77)**	2.92 (12.13)**	0.94 (4.31)**
Ln L/K	0.13 (0.78)	...	...	...	...
Ln K/L	...	0.37 (2.64)*	0.02 (0.37)	0.15 (1.61)	0.22 (3.09)**
Dr	2.14 (5.06)**	...	...	...	...
Df	0.21 (0.99)	-0.22 (-1.03)	0.04 (0.34)	0.12 (0.61)	0.05 (0.44)
S	...	...	...	...	0.83 (2.57)**
Dummies for location					
D ₁	0.08 (0.18)	0.73 (2.13)*	-0.58 (-2.96)**	0.41 (1.58)	0.11 (0.54)
D ₂	1.09 (3.39)**	-0.16 (-0.41)	-1.17 (-5.60)**	0.27 (0.66)	-0.78 (-3.34)**
D ₃	0.58 (1.64)	-0.07 (-0.17)	-0.24 (-1.22)	-0.10 (-0.38)	-0.25 (-1.31)
D ₄	0.01 (0.05)	-0.52 (-1.55)	0.65 (3.60)**	...	0.53 (3.06)**
D ₅	...	-0.09 (-0.25)	0.61 (3.91)**	...	0.34 (2.22)*
R ²	0.42	0.26	0.56	0.04	0.53
F	9.11	5.02	23.59	1.39	19.34
n	80	82	128	52	132
Elasticity of output with respect to					
L	0.13	0.63	0.98	0.85	0.78
K	0.87	0.37	0.02	0.15	0.22

Source: Based on data from Tshikala B. Tshibaka, "Food Production in the Zairian Basin, Zaire, 1982/83," Institut Facultaire des Sciences Agronomiques, Yangambi, Zaire, and International Food Policy Research Institute, Washington, D.C., 1986 (computer printout).

Notes: Dr is a dummy to reflect the date of introduction of rice in different communities, Df is a dummy to account for the length of the fallow period, and S is a dummy for the share of cassava in cultivated area to reflect the effect of the crop mix adopted.

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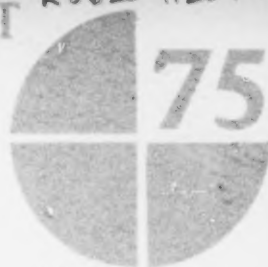
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IRRIGATION TECHNOLOGY AND COMMERCIALIZATION OF RICE IN THE GAMBIA: EFFECTS ON INCOME AND NUTRITION

Joachim von Braun
Detlev Puetz
Patrick Webb

August 1989

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**Research Report 75
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FOREWORD

With its focus on irrigation technology and commercialization of rice in West Africa, this study addresses the question of how agricultural growth in Sub-Saharan Africa may improve food security. Over the last few decades in Africa, rice has ranked second after maize among cereals that have contributed to the overall growth of cereal output. In West Africa, rice imports have grown rapidly during the last two decades. Future decisions on irrigation investments and technology choices will be of critical importance in view of numerous past failures and excessive costs of irrigation in Sub-Saharan Africa.

This research by Joachim von Braun, Detlev Puetz, and Patrick Webb is to be seen against the backdrop of policy priorities resulting from the earlier work of IFPRI and its collaborators on accelerating food production in Sub-Saharan Africa.

The study results highlight the measurable positive effect that incremental income in the hands of the poorest has on nutritional improvement. It is encouraging to learn that yield levels comparable to the highest yields in Asia can be obtained in irrigation schemes in Africa, but the issue of lowering irrigation costs remains a crucial one. In part, these currently high costs are due to the general lack of infrastructure in Africa. Another emphasis of the study is the identification of very high substitution effects between irrigated crops and rainfed crops because of swift labor movements between the crops.

The study comprehensively traces the nutritional effects of technological change in The Gambia via production, income, employment, and consumption effects in innovative ways. It stresses the need to consider cause and effect relationships in complex household economic systems. Having a multidisciplinary team of economists, anthropologists, and public health experts work on these issues has proven very useful.

A particularly noteworthy aspect of this study is the complex relationship between agricultural productivity and labor utilization. An increase in labor productivity may induce both fundamental changes in the intrahousehold system of division of labor and major shifts of labor between agriculture's subsectors. Emphasis is required in program design on breaking the labor bottlenecks in this environment under seasonal stress.

Among the important lessons of the study are that technological change is a key to improving food security at the household level in this West African environment, and that irrigated rice with appropriate technological considerations in the riverine areas can make a substantial contribution. To incorporate women farmers into the technologically driven modernization process, women must have access to the means that permit them to use the new technologies—especially access to inputs and credit. Food-security improvements in terms of reduced hunger are substantial and can be cost-effective with technological change, but health and sanitation constraints in environments with weak rural health services need to be alleviated jointly to reap maximum benefits from the agricultural commercialization process. The latter point confirms findings of comparable research by IFPRI in Guatemala and Kenya that health and sanitation services in rural areas have to move in tandem with the agricultural modernization process in order to reduce the nutrition problem along with the hunger problem.

John W. Mellor

Washington, D.C.
August 1989

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SUMMARY

Technological change in African agriculture is usually necessary, but not always sufficient, to achieve sustained increases in production. How can technical progress in a crop, and the resulting local growth in marketed surpluses of that crop (that is, the commercialization of traditional agriculture), be designed and complemented so as to improve the chances of African countries to (1) raise the aggregate output of crops, and (2) reduce poverty, improve food consumption, and advance nutrition, especially among vulnerable preschoolers?

This study examines such questions in the setting of a major technical improvement in rice production in a West African country. The study asks: To what extent does technical change raise production? Does such change encourage the diversion of labor from other activities into modern rice or into leisure as income rises? If extra production does materialize, does it increase income and consumption? If so, do the poor benefit from this? Does any such extra consumption affect adult and child nutrition? The links between production, income, consumption, and nutrition are explicitly established in the analysis.

The study focuses on a new rice irrigation project involving about 7,500 farmers in The Gambia. The study site was selected because households could be traced during and after the introduction of new rice production technology (mechanical pump irrigation and improved drainage for rainfed and tidal irrigation).

The empirical research is based on a detailed sample survey of 900 farmers in 10 villages. This sample includes both participants and nonparticipants in the irrigation project and covers the four major ethnic groups of the area, thereby providing a fair degree of representativeness for a wider part of the West African region, especially major parts of Senegal and Guinea. Account is taken of the complexity of production-consumption relationships in the large households that are typical of the region.

Production in the project takes place under fully water-controlled conditions (pump irrigation and drainage) that provide two crops per year, and also under partly water-controlled conditions (tidal irrigation or improved rainfed cultivation and drainage) that provide only one crop (in the wet season). Wet season yields in the fully water-controlled perimeters were 6.6 metric tons per crop per hectare in 1984 but dropped to 5.2 tons in 1985. In the same two periods, the partly water-controlled rice yielded 2.2 and 2.8 tons, respectively. Traditional rainfed rice (predominantly a women's crop grown in swamps) yielded 1.3 tons. Great variance in costs and net returns is observed between the technologies and between individual farmers using the same technology.

Average and marginal labor productivities are assessed in the context of the production system for the major crops. Average labor productivity (net returns per labor day) was highest for rice under pump irrigation (US\$2.45), followed by coarse grains (US\$1.50), groundnuts (US\$1.45), rice in the partly water-controlled project fields (US\$1.23), and traditional swamp rice (US\$0.95).

Most farmers at the project location grow both irrigated rice and upland crops. The expansion of modern irrigation has pulled labor away from the upland crops, causing a loss of 531 calories in other crops for every 1,000 calories gained in rice production—a net gain of 47 percent.

Men's overall labor input to agriculture is reduced when the household has more land in the project. Women's labor input, on the other hand, remains more or less constant. Hired labor accounts for 25 percent of the work in the pump-irrigated plots. Since hired labor played only a marginal role in rice production before the project, this reflects an increased use of hired labor in rice as a phenomenon associated with commercialization.

There was a specific attempt in this program to ensure access to project land by women, the traditional rice producers. Formal land titles for plots were given to female farmers. Yet the results were not as planned. Women continue to control 91 percent of traditional swamp rice fields, and even 77 percent of the partly water-controlled fields, but they control only 10 percent of the pump-irrigated plots.

Less of the new rice crop is sold for cash than expected—12 percent of total production from pump irrigation and 7 percent from partly water-controlled land. This compares with women's traditionally grown swamp rice, of which 21 percent is sold. This pattern of women selling relatively more than men is explained by the different institutional arrangements under which the crops are grown. The high-technology rice in the project has largely become a communal food crop for the common household pot under the compound head's control, while women's traditional rice is a mixed private crop (partly grown for cash) and communal food crop.

Protecting and enhancing women's productive role in agriculture is an important objective in itself. It is also important as an indirect path toward nutritional improvement. The study finds, however, that this objective cannot be enforced through bureaucratic means (formal land titles), which have little relevance in the field.

Average annual per capita income in the study area was US\$116 in 1985/86; agricultural income contributed 77.5 percent. Rice production in the project contributed 43.0 percent of income to the bottom income quartile (income per adult equivalent) versus 26.0 percent to the top quartile. The poor households thus benefit relatively more than do the upper-income groups in the area. At the sample average, the rice in the project increased real incomes by 13.0 percent per household.

An additional 10.0 percent of income leads to a 9.4 percent increase in food expenditures and a 4.8 percent increase in calorie consumption. The seasonal fluctuation in per capita calorie consumption is a problem of the poor and not of the total rural population. In the bottom income quartile, calorie consumption is 15.0 percent lower in the wet (hungry) season than in the dry season, but it remains constant and, indeed, sufficient in the top quartile. In the wet season, 49.0 percent of households in the bottom quartile consumed less than 80 percent of calorie requirements; only 2.0 percent of the top quartile fell below that level.

In the wet season, 35 percent of children under five years of age and 52 percent of those aged one to two years were found to be underweight. Lack of food, unclean water, and infectious diseases are identified as important determinants of nutritional status in multivariate analyses. Mothers' nutrition and health are considerably affected by seasonal work stress.

Household-level calorie consumption is a determining factor for differences in the nutritional status of children in the study area. A 10.0 percent increase in calorie availability per capita increases the weight-for-age indicator of nutritional status by 2.4 percent at sample means. This calorie elasticity of nutritional improvement is even higher in households with higher calorie deficiencies. To the extent that the new technology increased household income, and thereby calorie consumption, and to the extent that mothers' seasonal stress was reduced, the nutritional status of children and women has improved.

The study implies a set of policy conclusions for improved technology utilization, food security, and nutrition. A more broad-based policy and program emphasis on improvements in rural infrastructure, agricultural input delivery systems, and labor-saving technology for the peak season is called for rather than a focus on a single crop.

Rice irrigation shows promising potential in the study area, but technology choice and project design issues are complex. Specific suggestions related to choice of rice production technologies demonstrate opportunities for cutting costs in the respective technologies.

Measures are proposed to protect and enhance women's productive role in agriculture; for example, women's role as cash croppers and their lack of credit require more attention.

From a food security perspective, a wide distribution of small irrigated rice plots is needed across households and village communities in the area to reduce the adverse effects of seasonality and consecutive drought years on consumption. Such scattered distribution of the highly productive irrigated land results, however, in fluctuating yields, since in years of good rainfall labor is allocated more heavily to upland farming, while in drought years labor shifts more to the irrigated fields. Thus, good rainfall years appear bad for production in irrigated farming surrounded by upland farming with large year-to-year fluctuations of labor productivity. In the absence of well-developed rural financial markets, the food-security benefit of scattered land distribution (rather than creation of larger specialized rice farms) should be an important consideration despite the instability it induces in irrigation projects and the related project management burdens.

Finally, the study suggests that efforts to solve the nutrition problem can be furthered through more effective rural health services and sanitation (that is, drinking water) at the community level. The interactions between food shortage and morbidity, which establish the high prevalence of malnutrition in this study area, cannot be dealt with effectively from the food supply side only. The nature of the nutrition problem requires a strong focus on women (mothers) rather than on young children alone.

SCOPE OF THE STUDY AND CONCEPTUAL FRAMEWORK

An increasing number of low-income countries, especially in Africa, are facing crucial strategic decisions on how to cope with short- and long-term food-security problems. At the core of these strategic decisions is the appropriate choice of policies to promote technological change and increased market integration of crop production. This choice has to be addressed both for food crops for local consumption and for food and nonfood crops for export. This study is part of a larger ongoing effort at IFPRI that is aimed at improving understanding of the effects of technological change and commercialization at the household level.¹ The objective of this research is to provide planners and policymakers with insights that will help guide program design and policies that affect the process of technological change and commercialization in traditional agriculture. With such information at hand, potentially adverse effects of change on the consumption and nutrition of the poor may be avoided and the benefits enhanced.

In a broader sense, this study, with its focus on rice and irrigation, ties in with IFPRI's research (between 1979 and 1985) on rice policy in Southeast Asia and comprehensive studies on technological change of rice in Bangladesh (Hossain 1988). It also relates directly to IFPRI's research on changing consumption and production patterns in the Sahel, that is, the relative shift away from coarse grains (Delgado and Miller 1985), and evolves out of research priorities identified in IFPRI's collaborative efforts in Africa (Mellor, Delgado, and Blackie 1987).

The main research questions of this study are (1) How do technological change and commercialization affect resource use, income, consumption, and nutrition? (2) How can programs and policies for technological change in agriculture be designed in order to enhance the positive income effects of market integration and to cope with potentially adverse welfare effects? (3) Does the process of commercialization have adverse effects on the consumption and nutrition of selected groups of households or individuals within households? and (4) How can the rural poor, especially female farmers, be effectively integrated into the commercialization process? These general questions are tailored in this study to a case study in West Africa in which groundnuts are the principal cash crop and pump-irrigated rice production is a driving force of technological change and commercialization.

A few words are in order here to define *technological change* and *commercialization*. Technological change is understood as increased aggregate factor productivity, that is, the same output produced with fewer inputs or more output produced with the same amount of inputs, though the nature and composition of the inputs may be different.

Increased commercialization may occur with or without technological change. However, technological change rarely occurs without commercialization—at least on the factor-input side of production (seed, fertilizer, irrigation, hired labor), if not on the product-output side, leading to an absolute or relative expansion of marketed surplus. It should be underscored that in considering commercialization in this setting, the

¹ Studies following a similar approach have been undertaken by IFPRI in Kenya, the Philippines, Rwanda, and Guatemala.

study is not dealing with a typical situation that involves a change in crop mix, away from food crops for home consumption toward new crops grown primarily for sale. In this instance, the project under consideration introduced new technology for improved production of a single crop (rice) that was already grown and marketed locally to a limited extent.

The project was aimed at increased output and increased market integration through technological change in rice. Various irrigation technologies were introduced, comprising different packages of inputs and degrees of water control. In this study case, technological change and increased commercialization are closely intertwined, which suggests the need to carefully address costs of production along with expansion in output.

The relationships between technological change in food production, markets, and income and the effects of such change on food consumption and nutrition are complex. The more intricate the household organization and its production arrangements, the less straightforward these relationships are. However, if the food security of the rural poor is to be effectively improved and sustained, such links need to be thoroughly understood. Furthermore, a complete assessment of the multifarious effects of technological change requires an integrated view of households and of the markets in which they interact.

This study deals with the local- and household-level effects of technological change and commercialization in rice production. An attempt is made to identify and quantify the effects of such change in the spheres of employment, time allocation, labor productivity, income, and marketed surplus, and to determine how these affect consumption and nutrition. The special characteristic of the study is that the effects of change in production and marketing are traced through to the relevant consumption and nutrition effects. Considerable research exists covering individual aspects of the chain of events depicted in Figure 1,² but so far very little empirical research has attempted to trace the interconnections of the major elements of this chain, especially in Africa.

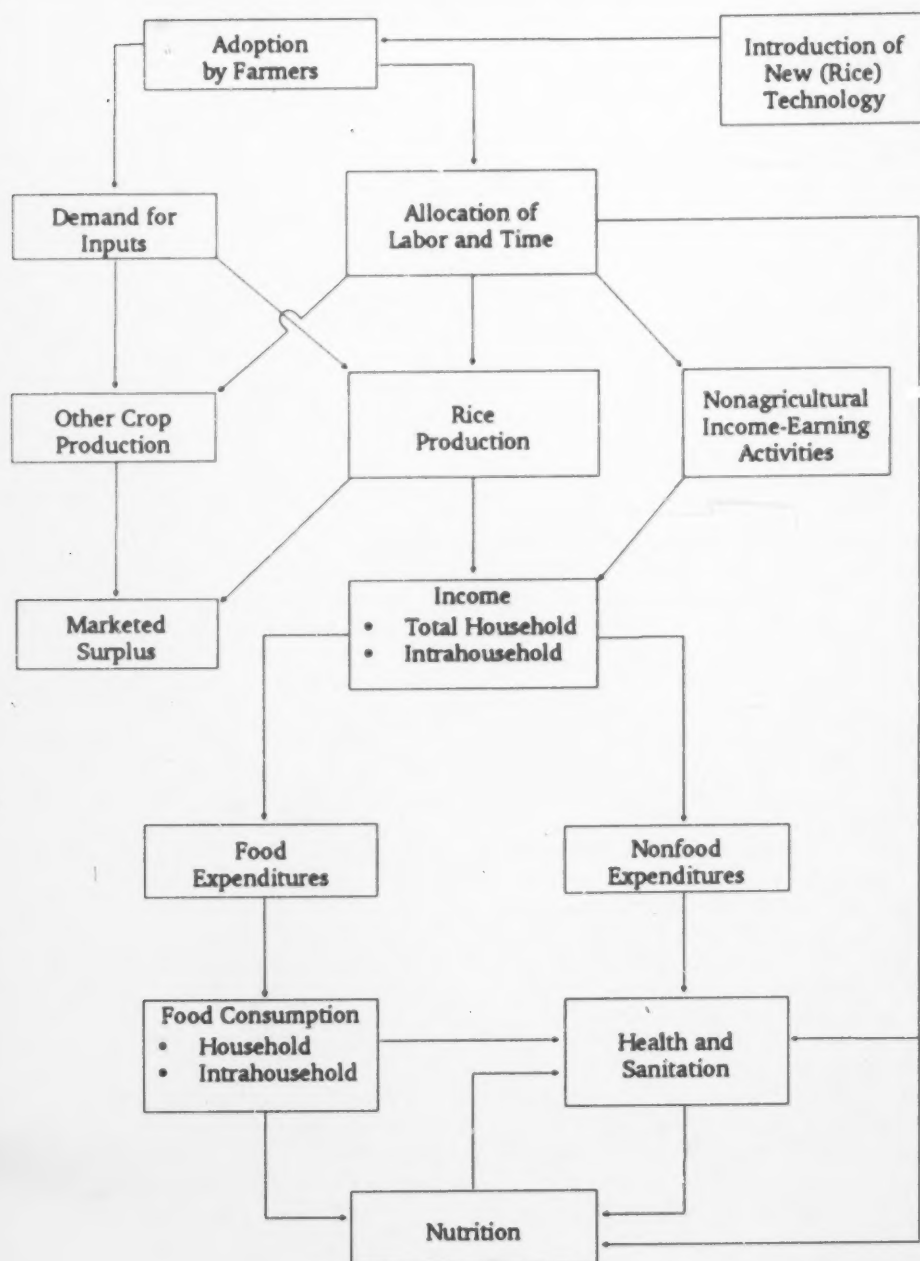
While the study takes an integrative view of household production, consumption, and marketing decisions, it refrains from building the analysis on an integrated household model,³ but rather conceptualizes the set of problems in terms of partial analyses within the framework of Figure 1. This route was chosen because the complexities of numerous structural relationships in the household production-consumption system would have been lost at the necessarily higher level of aggregation required for a closed household model. Also, the largely cross-sectional nature of the data suggests a cautious approach. There are inherent problems with unobserved latent variables and lack of independence among observations in a cross section. It is desirable to invest in building more longitudinal data sets in the long run to avoid these problems.

Figure 1 shows the conceptual framework followed in the analysis, at the same time providing an outline of the main themes covered by the report. The effects of technological change and commercialization on nutrition are mediated through (1) the nature of the new technology, (2) the adoption process and its production and income effects (and the resulting effects on employment and time allocation), (3) expenditure patterns and food consumption (which may not be uniform among the individuals of a household), and (4) the health environment that impinges on nutrition. The latter may be affected by expenditures on health and sanitation and by time-allocation effects of technology adoption "upstream" in the diagram (for example, mother's time allocation) or changes in the physical environment.

² A review of literature on the issue is provided in von Braun and Kennedy (1986).

³ On household models and their potentials for policy analysis, see Singh, Squire, and Strauss (1986).

Figure 1—Conceptual framework for analysis of household-level effects of new technology and commercialization



A better understanding of these critical relationships is essential to an identification of efficient modes of intervention designed to improve nutrition. The adoption of a given package of new technologies may involve certain trade-offs; for example, it may raise income but impose negative time constraints on child care. An early identification of such trade-offs and the design of corrective program components are essential to avoid short-term adverse effects of technological change on the poor.

The main methodological steps in the study, following the conceptual framework depicted in Figure 1, are the model analysis on access to new rice technology and adoption, the labor allocation model, the production function analysis, the marketed surplus analysis, the income earnings model, the food (energy) consumption model, and the models explaining nutritional status in the context of the health situation.

These models are designed so that the explained variables "upstream" in the diagram become explanatory variables "downstream" in the chain from technology to production to income to consumption to nutrition. But some feedback mechanisms should also be expected to work; for instance, better nutrition improving labor productivity. However, the intricacies of interactions in the household production system on the ground make the actual approach more complex than is depicted in the simplified diagram.

A brief sketch of the rationale and flow of analysis will be given here at the outset. Details follow in the respective chapters. The model sketches below are simplified and do not provide the specifics of variable definitions, precise units of observation, or time lags, but rather an overview on the flow of analysis and the conceptualization of exogenous and endogenous relationships in this analysis.

The introduction of new rice technology is treated as exogenous in this setting, but the degree of access to it by household units (compounds) is endogenous. The amount of land under new rice technology acquired by the household unit (HHACC) is hypothesized to be a function of location of village in project area (LOCATION), ethnicity (ETHNIC), demographics of household (HHDEMO), household status in local hierarchies (HHSTAT), and household wealth (WEALTH):

$$\text{HHACC} = f(\text{LOCATION}, \text{ETHNIC}, \text{HHDEMO}, \text{HHSTAT}, \text{WEALTH}). \quad (1)$$

This research, as well as the project around which it centers, is particularly concerned with the access of women—the traditional rice growers in the area—to the new rice technology. The probability of whether or not an individual woman within a household obtained access to land in the project (WOMACC; 1 or 0) is then hypothesized to be determined by the woman's demographic (WOMDEMO) and status characteristics (WOMSTAT) and by the degree of access of the household as a whole (HHACC, as dealt with in equation (1):

$$\text{WOMACC} = f(\text{WOMDEMO}, \text{WOMSTAT}, \text{HHACC}). \quad (2)$$

Introduction of new technology in one crop may substantially affect allocation of scarce resources to that crop and thereby reduce resource allocation to other crops. The focus is especially on the (re)allocation of labor (LABOR) by crop (j) as a consequence of access to new rice land (HHACC), because the new rice technology requires a lot of incremental labor input. Also included in this analysis of labor input is a set of variables depicting production conditions (PRODCON), labor force structures (LABSTRUC), and capital stocks (CAPITAL):

$$\text{LABOR}_j = f(\text{PRODCON}, \text{LABSTRUC}, \text{CAPITAL}, \text{HHACC}). \quad (3)$$

On the basis of crop-specific production functions (equation [4] below), whose main purpose is to estimate marginal labor productivities in this analysis, marginal output effects are derived from the estimated changes in labor allocation as a consequence of technological change in rice. The production functions for crops (j) consider labor input (LABOR $_j$), land and land characteristics (LAND $_j$, LANDCH), fertilizer use (FERT $_j$), technology use, such as appliances (TECHNO $_j$), and institutional arrangements under which the respective crop is grown, such as individual or communally grown crop (INSTIT $_j$), to depict the technical input-output relations in production (OUTPUT $_j$):

$$\text{OUTPUT}_j = f(\text{LABOR}_j, \text{LAND}_j, \text{LANDCH}, \text{FERT}_j, \text{TECHNO}_j, \text{INSTIT}_j). \quad (4)$$

Following the production analysis, the effects of change in output level and output composition are traced to their income and marketed surplus effects. The marketed surplus analysis focuses on the marketed outputs of cereals (OUTPUTMA $_j$), and attempts to explain these by the cereal production (CERPROD), prices (PRICE), income levels (INCOME), household demographics (HHDEMO), structure of crop composition along gender lines (WOMCER), and market-related infrastructure variables (INFRA):

$$\text{OUTPUTMA}_j = f(\text{CERPROD}, \text{INCOME}, \text{PRICE}, \text{HHDEMO}, \text{INFRA}). \quad (5)$$

In assessing the net income effects of technological change in agriculture at the household level, not only should the substitution effects in agricultural production be traced, but also those between farm and nonfarm income-earning activities. This is done in the context of an income-earning model in which income per capita (INCOME) is explained by upland crop-related agricultural capital (tools) and livestock capital (AGCAPITAL), human capital-related variables (HUCAPITAL), household demographics (HHDEMO), ethnicity (ETHNIC), and access to the new rice land (HHACC):

$$\text{INCOME} = f(\text{AGCAPITAL}, \text{HUCAPITAL}, \text{HHDEMO}, \text{ETHNIC}, \text{HHACC}). \quad (6)$$

The effects of changes in total budget availability (cash and in-kind) on spending patterns of households are then analyzed, and the effects on basic food consumption (calories) in the two main seasons of the year are modeled in greater detail. The conventional approaches of demand analysis are followed, enriched by structural variables that are determined by the local situation concerning food-consumption decision-making in the complex and large household units. Increased income is expected to raise food energy consumption per adult-equivalent person (CALORIE) but decreasingly so at the margin. The income effects are subject to the price situation (PRICE),⁴ given a certain composition of household (HHDEMO), nature of the income stream (cash share [CASHSH]), and income control in the household unit (women's share [WOMCON]):

$$\text{CALORIE} = f(\text{INCOME}, \text{PRICE}, \text{HHDEMO}, \text{CASHSH}, \text{WOMCON}). \quad (7)$$

Finally, the effects of food consumption (CALORIE) are traced to the nutritional status of children and women (NUTSTAT). Of course, numerous interweaving factors,

⁴ The role and potentially endogenous characteristics of consumer purchase prices in this model (equation [7]) and of producer sales prices (see equation [5]) due to seasonal variations are to be reviewed and are discussed in the respective sections of the report.

in addition to household-level food energy consumption (per adult equivalent), determine the nutritional status of children as quantified by anthropometric measures. Child-feeding practices, children's demographics (CHDEMO), household demographics that are important for the child-care environment (HHDEMO), the health record of child and mother (HEALTH), and the sanitation environment (SANIT) are most relevant. Also tested is whether increased access to new rice land with the new production technology had an additional effect on nutritional status besides those explanatory factors:

$$\text{NUTSTAT} = f(\text{CALORIE}, \text{CHDEMO}, \text{HHDEMO}, \text{HEALTH}, \text{SANIT}, \text{HHACC}). \quad (8)$$

The research was undertaken around the Jahally-Pacharr Smallholder Rice Project that is described in Chapter 4. The analysis is based on a series of sample surveys in 10 villages randomly selected from baseline information and 168 households (compounds) selected randomly in these villages. In some instances, these compounds are very large (up to 80 persons) and are subdivided into separate subunits of decisionmaking for production and consumption management. Taking this into account, there were 214 household units in the survey (for details on sampling, see the Appendix).

The main objective of the sample selection was to identify households that are, first, representative of the participants of the rice project and, second, involved in it to different degrees, thus providing the opportunity for a cross-sectional analysis of the project's effects on income and nutritional status. Since project land was distributed to villages according to traditional tilling rights in the swamps, a fairly large variation in plot size per capita is apparent for households between, and even within, different villages.

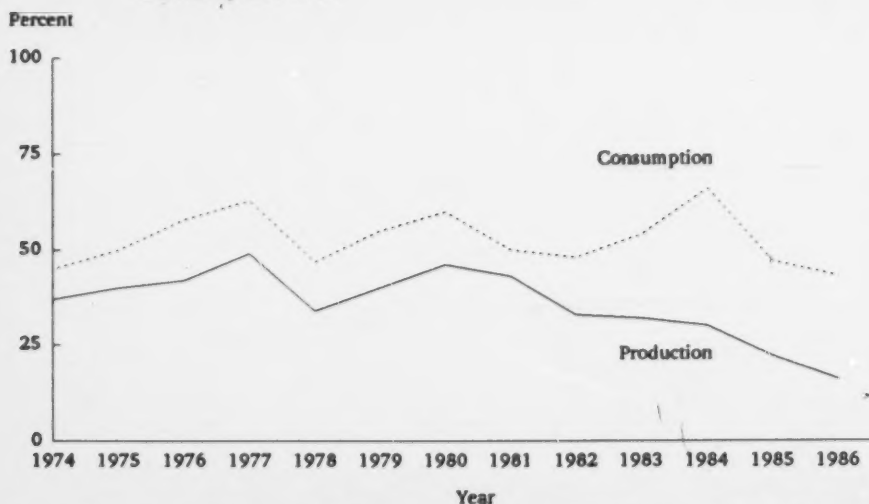
THE STUDY AREA AND ITS COMMERCIALIZATION THROUGH AGRICULTURAL PROGRAMS

The share of rice in total cereal consumption is traditionally high in The Gambia compared with neighboring West African countries. But domestic production in The Gambia has not kept pace with consumption growth, and the share of rice production in total cereals has declined, leaving a widening import gap (Figure 2). Better understanding of microlevel production relationships in the cereals sector and of rural consumption patterns and their determinants is required to design policies to cope with this import gap. This study contributes to the closing of related research gaps.⁵

Agriculture in the Study Area

The study area is located 300 kilometers east of Banjul on the south bank of the Gambia River (Figure 3). Population density is roughly 57 people per square kilometer. The area is inhabited by four different ethnic groups (Mandinka, Wolof, Fula, and Serahuli). Their villages range in size from 50 to more than 2,000 inhabitants, while their households have from 1 to over 80 people (the national average is 16). The

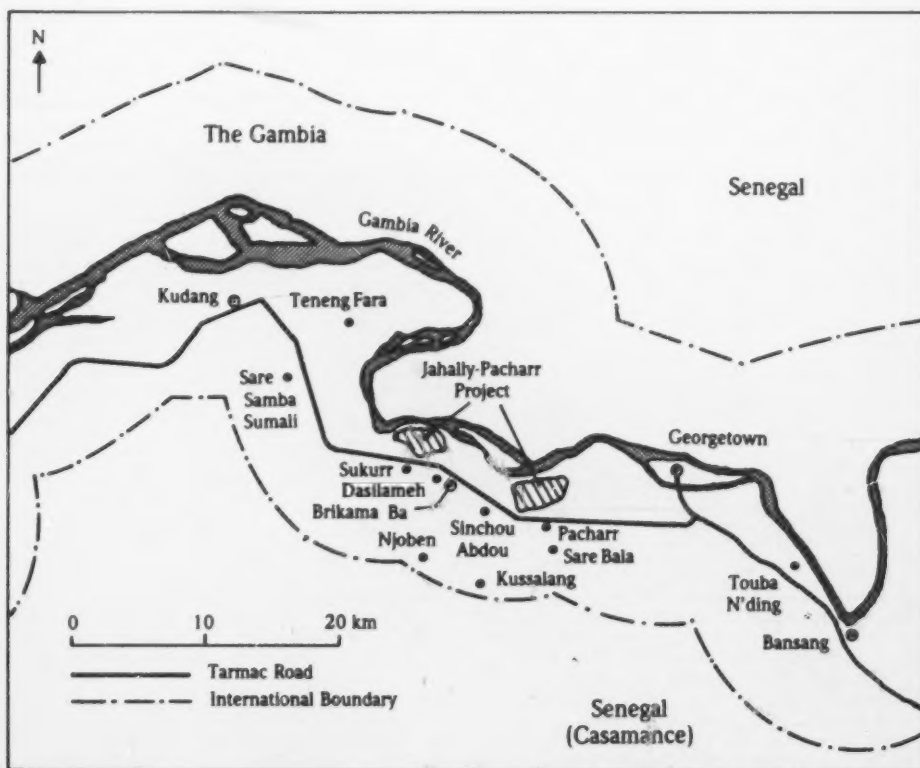
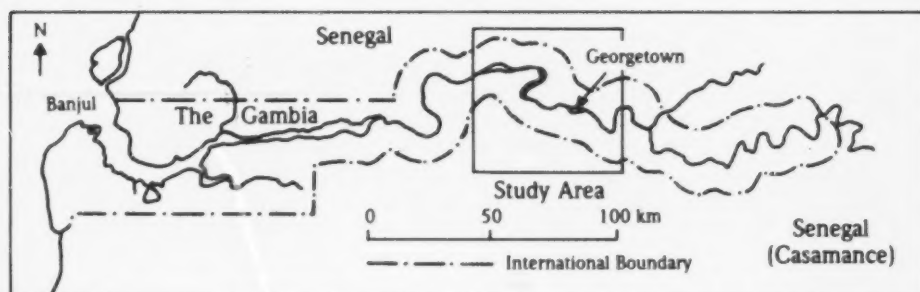
Figure 2—Share of rice in total cereal production and consumption in The Gambia, 1974-86



Source: Ken Johm, "National Production and Consumption Trends and Their Implications," in *Policy Issues for Rice Development in The Gambia*, ed. Sambou Kinteh and Joachim von Braun (Washington, D.C.: International Food Policy Research Institute, 1988).

⁵ A larger research effort on these issues is ongoing at IFPRI for the Sahel countries.

Figure 3—Map of the study area



Note: Survey villages are indicated with a black dot. Small towns in the area are shown with a circled dot.

population is almost entirely Muslim. Agriculture in this area is dominated by the seasonality of rainfall and the related cropping season from July to December. Groundnuts—the traditional and principal cash crop—cover almost 48 percent of the upland cultivated area in the sample villages (Table 1).⁶ The support system for groundnuts includes fertilizer credit, seed-improvement programs, and marketing arrangements. A number of other upland crops have also been promoted in the study area, but on a more minor scale. For example, a program promoting production of cotton (the secondary cash crop) was recently initiated with a subsidized input package. A small maize improvement scheme is also active in some of the villages in the study area. However, millet, the most important upland cereal, has largely been neglected.

This is in contrast to rice, which has been given the most support of all the staple foods, especially through irrigation schemes set up by the Taiwanese and the World Bank in the late 1960s and 1970s. Most of these schemes, however, have deteriorated, and they played only a minor role by the time the irrigation project that forms the focus of the present study was established in 1983/84. This project, the Jahally-Pacharr Smallholder Rice Project, has been the single most important factor in transforming agriculture in this area. A description of the project in the context of earlier rice projects is given in Chapter 4.

The commercialization process in the study area is not limited to groundnuts or to the influential rice project, but these, along with the smaller initiatives (cotton, maize),

Table 1—Shares of land area cultivated, by major crops, wet season 1985

Crop	Gambia Total	MacCarthy Island Division	Sample Villages ^a	
			Upland Villages	Lowland Villages
			(percent)	
Fully water-controlled rice in project ^b	0.3	1.0	2.7	10.0
Partly water-controlled rice in project ^c	0.3	1.0	1.9	7.0
Old irrigated rice schemes ^d	0.4	1.0	...	...
Swamp rice	10.0	13.0	1.0	18.0
Early millet	20.0	27.0	32.6	16.0
Late millet	9.0	1.0	0.7	2.0
Sorghum	5.0	5.0	3.9	5.0
Maize	8.0	9.0	7.0	10.0
Groundnuts	46.0	42.0	47.6	27.0
Cotton	1.0	1.0	2.6	5.0
Total	100.0	100.0 ^e	100.0	100.0

Sources: Data for the Gambia total and MacCarthy Island Division are from *The Gambia, 1986/1987 Agricultural Sample Survey Report* (Banjul: Planning, Programming, and Monitoring Unit, 1987); data for the sample villages are from the 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Upland villages in the sample are Njoben, Sinchou Abdou, Kussalang, Sukurr, and Sare Bala; the other villages are in the lowlands (see Appendix Table 57).

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^d These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^e Parts do not add to total because of rounding.

⁶ Besides being commonly known as a cash crop, groundnuts are an important food crop that provides a substantial share of the calorie and protein consumption requirements of the rural population.

drive the process. In addition, farming activities in livestock and vegetable production, as well as activities in the nonfarm income-earning arena (both inside and outside of the area, including resultant remittances) play a significant role in the overall market integration of the region under consideration.

Population and Infrastructure Characteristics

The population of the study area is relatively young. It was estimated that 43 percent were under 15 years old and barely 6 percent were over 60 years old.⁷ The overall sex ratio was 0.965 but this included large fluctuations within the age groups. Sixty-four percent of women aged 15-19 were married, compared with only 4 percent of men. A sample of women aged 40-59 reported having had an average of 7.2 live births of which, on average, four children were still alive.⁸

The majority of farmers involved in the study area belong to one of the four principal ethnic groups that inhabit the region: the Mandinka, Wolof, Fula (also known as Peul or Fulani), and Serahuli (also known as Sarakole). Although the study site is located entirely in The Gambia, the coverage of the various ethnic groups gives this study a substantial degree of representativeness for household systems in West Africa, since the four groups are widely spread and significant throughout this part of the region (Figure 4).

Long-standing cooperation and a marked absence of ethnically based rivalry or animosity have led to all four groups living peaceably side by side in neighboring villages or even within the same village. However, there are a number of distinctions between certain types of villages.

Upland and Lowland Villages

The first distinction to be drawn between villages is that of geographical location, which partially dictates the types of crops that can be grown at a given site. Gambian villages take the form of nuclear settlements. The land to which each village lays claim forms a band of varying width around the inhabited core. This band is not necessarily continuous or concentric, but is like a mosaic of fields scattered at various distances around the concentration of dwellings.

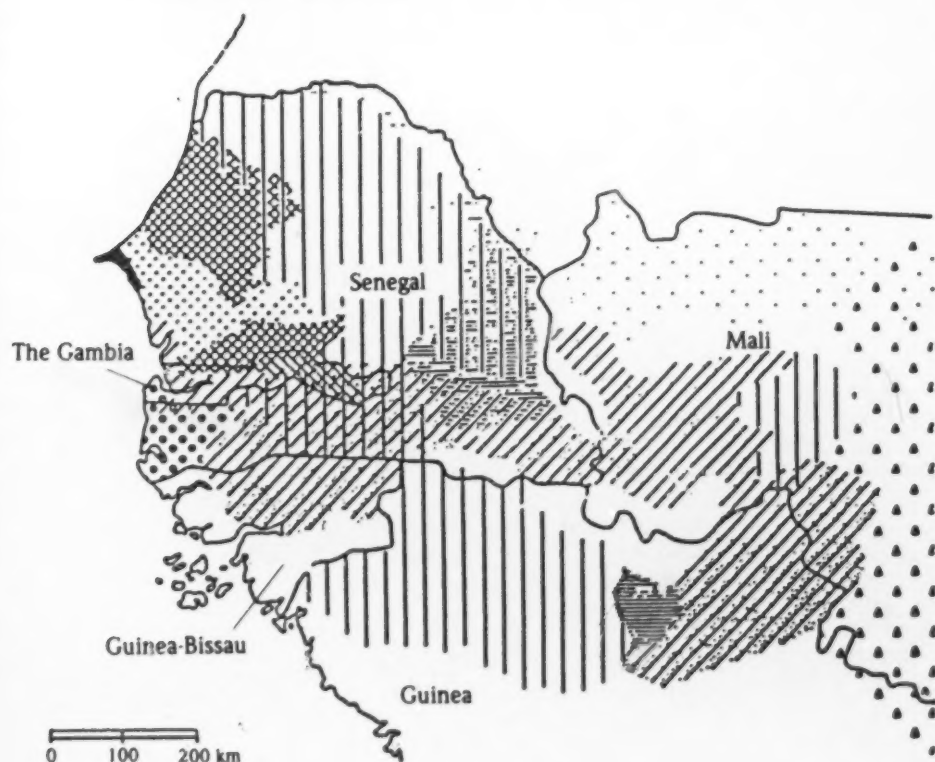
Depending on the village's location, this land is made up of either sandy detrital sediment of relatively low chemical fertility (upland soils) or more fertile hydromorphic soils located closer to the banks of the Gambia River and its tributaries (lowland soils) (Dunsmore et al. 1976). As a result of these soil characteristics, the agriculture of the upland villages traditionally leans toward upland cereal crops and livestock husbandry, while the lowland villages, although they have access to both types of land, traditionally place a much greater stress on rice.

While the distinction between upland and lowland villages should not be used too rigidly (because no place in The Gambia is more than 20 kilometers from the river), this is a useful division that will be referred to repeatedly in the analysis. Lowland villages can generally be equated with "traditional rice tillers" status (allotting an average of 18 percent of their total land area to swamp rice), while upland villages

⁷ Round 1 data for those present.

⁸ The sample consisted of all mothers or caretakers of children under 10 years of age.

Figure 4—Distribution of major ethnolinguistic groups in The Gambia and neighboring countries



Ethnic Groups

	Mandinka		Serahuli		Jola
	Wolof		Lebou		Toucoulor
	Fula		Serer		Bambara

Source: Kenneth Swindell, *Farm Labour* (Cambridge: Cambridge University Press, 1985).

have generally turned to rice production only in recent years and allocate only 1 percent of their land to swamp rice (see Table 1).⁹

Ethnicity, Size, and Growth

The second major distinction to be drawn between the 10 sample villages is their ethnic and historical background. As shown in Table 2, the sample includes a mixture of ethnicities in both the upland and lowland villages. The two villages not involved in the irrigation project are Mandinka. Not every village is ethnically homogeneous, however, and the ethnic label attached to each village refers to the predominant group of inhabitants.

Table 2 shows that two of the sample villages (one Fula and one Mandinka) are at least 100 years old. Another four are over 50 years old, but the remaining four have been founded since the late 1950s. Sinchou Abdou, the newest village, was settled in 1981 as a direct consequence of the Jahally-Pacharr project: the present village chief had suffered poor crops for several years as a result of drought and decided to move when he heard about the forthcoming irrigation scheme.

Sinchou Abdou was established by Gambians moving from one site within The Gambia to another. Yet not all of the sample villages have such origins: two were founded by migrants from Guinea Bissau, one is of Guinean origin, and two were settled by immigrants from Senegal. The 10 villages also show considerable diversity in size and in their recent rates of growth. During 1975-85, Pacharr expanded the

Table 2—Ethnic and historical characteristics of the sample villages

Village	Ethnicity ^a	Approximate Age of Village (years)	Founders' Country of Origin ^b	Number of Compounds in 1986	Population	Change in Number of Compounds 1975-85 (percent)
Upland villages						
Kussalang	Fula	100	Guinea	18	200	0
Njoben	Wolof	60	Senegal	50	1,200	+ 52
Sare Bala	Fula	17	Gambia	7	90	+ 17
Sukurr	Serahuli	27	Gambia	10	200	0
Lowland villages						
Dasilameh	Mandinka	80	Guinea Bissau	50	450	+ 56
Pacharr	Mandinka	100	Guinea Bissau	59	750	+ 136
Sinchou Abdou	Fula	5	Gambia	15	150	^c
Sare Samba						
Sumali	Fula	30	Gambia	16	130	+ 7
Nonproject villages^d						
Teneng Fara	Mandinka	80	Senegal	12	140	+ 50
Touba N'ding	Mandinka	60	Gambia	12	140	-20

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Few villages are ethnically homogeneous; this refers to the dominant group.

^b Country from which the village founders migrated to establish their present home.

^c Village founded in 1981.

^d Not involved in Jahally-Pacharr Smallholder Rice Project.

⁹ Table 1 shows that upland villages have a higher percentage of their total land in the form of project tidal-irrigated land than do the lowland villages. This is because the lowland villages (being traditional rice tillers) have priority for the best project land (pump-irrigated), leaving the lower-yielding tidal land to the upland farmers.

most rapidly (+ 136 percent), followed by Dasilameh (+ 56 percent), and Njoben (+ 52 percent). In other words, the three largest villages in the sample were also the fastest-growing villages during the decade preceding the study. Two of the upland villages (Kussalang and Sukurr) exhibit zero growth rate for this period, and only one village, Touba N'ding (outside the area of the rice project), shows a negative growth rate.

Services and Infrastructure

The next area of differentiation between villages relates to their access to infrastructure and services. Five of the sample villages are located less than 1 kilometer from the main tarmac road that runs the length of the country from Banjul to Bassé. These five villages are also only 5 kilometers or less from the project site. The remaining three villages involved in the project are located between 3 and 8 kilometers from the road, which places them 6-11 kilometers from the project rice fields (Figure 3).

Only one of the sample communities, Njoben, is served by a primary school in the village itself. Children in the other villages have to walk sometimes considerable distances each day to the nearest state-run school. Similarly, only one village, Pacharr, has a daily market within its confines. The other nine villages are located between 2 and 8 kilometers from such a market. Njoben, one of the villages farthest away from a daily market, compensates by having four small shops that sell durable commodities such as matches, kerosene, and batteries.

In addition to daily markets, a much larger market (attracting traders from as far as Banjul and Kaolack in Senegal) moves up and down the country each week. Villagers from Teneng Fara and Sare Samba Sumali visit it when it stops in Kudang. The inhabitants of Touba N'ding attend the market when it reaches Bansang. And all the other communities are within reach of the Brikama Ba stop.

In terms of health facilities, the only clinics providing rudimentary curative medicine are at Brikama Ba, Bansang, and Kudang (all on the tarmac road). Dasilameh's inhabitants are fortunate in living less than 1 kilometer from the Brikama Ba clinic. However, the other project-involved villages are also served by this one clinic, and their access to and use of its facilities are limited by distance (up to 20 kilometers in the case of Kussalang).

Every village has at least one "clean" well that is used as the principal source of drinking water for the community. Pacharr is unusual in having 17 such wells. A water analysis was carried out in all the sample villages in the dry season to discern whether there were major differences in quality that might affect the health of their inhabitants. The water analysis was conducted by quality control officers of the Ministry of Water Resources under contract with IFPRI. They took three samples from the main well in each village during the first week of September 1986, and carried out a coli count on site. The results indicate that Dasilameh, Sukurr, and Pacharr all enjoy relatively unpolluted water sources, while the other villages have access to less-clean water as measured by coli count. The significance of this factor for nutritional status of children is tested in the multiple regression analyses later in this paper and shows as significant.

Nonfarm Employment and "Strange Farmers"

A final set of distinctions may be drawn between the sample villages on the grounds of nonfarm activities and the functioning of local capital markets. Nonfarm income-earning activities, such as thatching, potting, and smithing, are found in all the villages. In some cases, there is only a handful of craft workers in a community. Kussalang, for instance, contains only three, and Sare Bala and Teneng Fara have only four each. Yet in the larger communities the number of craftspeople rises to a dozen or more. Sukurr is a special case; although only a small village, it has 24 craft workers among its farmers.

This is because two large households in Sukurr are traditional goldsmithing families and all the sons learn the art of smithing, while all the daughters learn the art of potting (a traditional association of the two skills by sex).

The same variation can be seen in the numbers of *marabouts* and "Strange Farmers" in each village. *Marabouts* are religious instructors who earn an income from teaching Koranic studies and from making magical charms. The new village of Sinchou Abdou has no *marabouts* yet among its inhabitants, in contrast with Dasilameh and Njoben, which have seven and eight, respectively. Strange Farmers are migrant workers who live in a village for one or more seasons, earning the right to grow a cash crop by exchanging their labor with a host for land and lodgings.¹⁰ Such agricultural migrants are attracted to the communities with the most "surplus" land, the best farm tools, and the best infrastructure. Pacharr and Njoben, for instance, had 50 and 61 Strange Farmers, respectively.

Functioning of the Economy at Village and Compound Levels

Interactions within the Village

Each village comprises an amalgamation of households, generally referred to as compounds, that are clustered around a central point usually occupied by a silk cotton tree, a well, and a shady meeting place.

There are strong village hierarchies defined by lineage status (a form of caste system whereby former slave-owning compounds rank at the top of a status pyramid, followed by village-founding compounds, free compounds, artisan compounds, and finally, ex-slave compounds) and by duration of residence in the village (Haswell 1953, Dey 1982). At this level, interpersonal relations are controlled by the village chief and council of elders.

Differences in approach to control of the village are manifest in a number of aspects of village organization. For example, to help poor or sick farmers, all 10 sample villages arrange communal work groups to which every compound is expected to send a representative. However, some villages gather for such communal work more often than others: Dasilameh reported 48 such engagements a year. Touba N'ding organizes such groups roughly 24 times a year. Njoben, although a substantially larger village than Touba N'ding, calls the communal work group together only 4 times a year.

Of course, compounds in Njoben, as in all other communities, can have their own individual cooperative arrangements to serve as bilateral support systems. Labor, tools, food, and many other resources are exchanged between family groups in the same village. While the large survey undertaken for this study captures the main transactions (for instance, labor and food), an in-depth study further explores these linkages (Webb 1989). Such links may also include the exchange of youths for marriage and often date back several generations. It is unusual for any given compound to enjoy close links with fewer than three other compounds in their community.

The Compound Economy

The Gambian compound is the structure that serves as the arena for family interactions. In physical terms, the compound constitutes a collection of dwellings, kitchens, and storage huts clustered around a central courtyard and fenced off from the pathways outside. The average number of people living in the compounds studied was 13.7 but

¹⁰ For more details of the Strange Farmer system, see Swindell (1985) and Robertson (1987).

the range was from 2 to 86. Compound size was related to ethnicity (Serahuli had the largest mean, 19.4 persons, and Fula the smallest, 11.4 persons). Size was also related to age. New compounds tended to be smaller; those less than 1 year old averaged 8.3 persons, while those over 10 years old averaged 15.8.

The nucleus of the compound membership is a grouping of blood-related kin, but the total household may also include more distant relatives and even unrelated Strange Farmers among its inhabitants. Each household member holds a well-defined position in the compound micro-society that is ascribed according to hierarchies of age, sex, and marital status.¹¹ Ultimate responsibility for the maintenance of productive cooperation lies with the compound head. Yet the compound head is not omniscient. However powerful and domineering a single figure of authority may be, it is impractical for one person to make all the decisions that are necessary in the running of a large household of diverse individuals. Subdivisions of distinct spheres of responsibility and activity are apparent in many (especially larger) compounds.

The Compound Subunits

There are two main kinds of subdivision of the compound unit. On the one hand, compound membership may be subdivided into *dabada* and *sinkiro*. On the other hand, the compound farm is divided into a communal *maruo* section and private *kamangyango* sections.¹²

The *dabada* (a Mandinka word deriving from the noun *daba*, or hoe) is generally defined as a farm production unit. If all members pool labor to produce food on which the compound subsists, then the *dabada* is coincident with the compound. This is the case in 86 percent of the sample compounds. If, however, two or more groups of individuals living within the same compound decide to split their farming ventures, then that compound may contain as many as four *dabadas* (the sample contains 16 compounds with two *dabadas* and four compounds with four *dabadas* each). *Dabada* structures change frequently. Therefore, production data were gathered on an individual field-by-field basis from each person responsible for fields in each whole sample compound.

Cooking and consumption groups, called *sinkiros* in Mandinka, provide the basis for the compound's organization of storage, processing, and consumption of food. In larger *sinkiros* several women may be responsible for cooking; typically, each woman cooks on a rotational basis. The head cook of the *sinkiro*, usually the highest-status active female, supervises the cooking procedures, establishes the duty roster of the cooks, and organizes the provision of ingredients.

The cooked food is normally divided into a number of bowls that are presented to "eating groups." Many combinations of these eating groups are possible in a compound by age and gender. Sometimes people from different *sinkiros* join in eating groups, but rarely people from different compounds.

Among the Mandinkas, the women of the same *sinkiro* traditionally also work together as a distinct production unit. A *sinkiro* is thus not just a cooking unit in these instances where the women produce traditional rice as both a communal and an individual crop independently from the male-headed *dabadas*.

In most of the sample households, the *dabada* and *sinkiro* units coincide with the compound (80 percent of the compounds have only one *dabada* and one *sinkiro*). Some

¹¹ For a more detailed account of the decisionmaking structures of intracompound hierarchies, see Webb (1989).

¹² For complementary accounts of Gambian household organization, see Dey (1982) and Dunsmore et al. (1976).

of the larger compounds may be subdivided into several working and consumption groups. Ethnicity plays a role in this pattern. In the study area, this applies especially to Mandinka and Wolof compounds, where some of the traditional responsibilities of the compound head are transferred to the heads of the subunits.

In subdivided compounds, where the number of *sinkiros* equals the number of *dabadas*, all persons of one *sinkiro* usually also belong to the same *dabada* and the other way around. But sometimes *dabada* and *sinkiro* may differ: people from different consumption groups may pool their labor in one working group and share the produce after harvest. Such situations apply to 15 of the sample compounds. In these cases, the *sinkiro* was identified as the most stable and important decisionmaking unit for production, storage, and consumption decisions, even when agricultural production was technically organized partly in a different working unit. The final decision about the appropriate unit of observation was taken only after careful evaluation of each of the more complex cases of nonidentical production and consumption units within compounds.

The compound farm is also divided into two distinct parts: the communal *maruo* farm and the private *kamangyango* farm (communal refers to compound or *dabada* level, not to village level).

The *maruo* farm comprises a set of fields that is designated to provide the bulk of the food that will be required by the household until the following harvest. This enterprise, fundamental to the maintenance and survival of the compound group, is under the control of the compound head, either directly or through a production manager.

The harvest of a *kamangyango* field, by contrast, is allocated for individual rather than communal disposal. Any person in the compound (including the compound head) has the right to a *kamangyango* field for which he or she will be solely (or sometimes jointly) responsible. The number of *kamangyango* fields is naturally limited to the stock of land available to the compound and to the extent to which the head is prepared to subdivide existing fields. Boys and girls frequently get their own *kamangyango* field before the age of 14.

The communal crops are produced by the combined labor of all compound members—all men and women have a customary obligation to provide labor to the communal fields. Labor for the private crops, on the other hand, is organized by the individual who is responsible for the field. Individuals can choose to provide as much or as little labor to this crop as they want. However, this becomes one of the focal points of competition between personal interest and cooperation with the rest of the compound group. For those men and women with access to private fields, time spent on the communal farm or on other people's farms is time spent away from private crop production. And time spent on the private farm is time away from communal food production and time away from helping others.

This problem of balance between cooperation (adding to total availabilities) and conflict (dividing total availabilities among the members of the household) constitutes one of the so-called "bargaining problems" discussed by Sen (1985). The most common way that compound heads attempt to resolve the problem is to assign two or three days in the week as *maruo* workdays, on which all able-bodied compound members are expected to provide labor to the communal fields under the direction of the head, and the rest of the week as *kamangyango* workdays, during which individuals may allocate their own labor as they please. This allocation of up to three or four days a week to private farming results in a considerable amount of intrahousehold labor sharing at the individual level. Rather than pursue an individualistic concentration of labor

inputs on their own plots, most farmers appear to favor a high level of cooperation among household members.¹³

Intrahousehold cooperation in the spheres of labor exchange and resource control was found to be an important factor in the successful adoption of the technology package offered by the Jahally-Pacharr rice project.

¹³ This aspect is covered in von Braun and Webb (1989).

PRODUCTION EFFECTS OF COMMERCIALIZATION AND TECHNOLOGICAL CHANGE IN RICE

The country's first step toward expanding and improving rice production was taken in 1948 by the British Colonial Development Corporation. This initiative was driven by a desire to reduce costly food imports, which had become a necessity to offset frequent shortfalls in food production in various parts of the country caused by drought and insect damage. The swamps around Pacharr in the present study area were selected as the site for a planned 9,200-hectare irrigation scheme. Irrigation was achieved through the canalization of leveled fields, fed by the tidal flow of the river. The scheme was run on a plantation basis, with heavy work carried out by tractor; local labor was required only as daily paid hands for weeding. The first 60 hectares were planted in 1950, but only 6 hectares survived flooding that year because of insufficient drainage. Also, the heavy machinery was difficult to operate in the slippery conditions. Therefore, it was decided to involve local farmers on a sharecropping basis, but the scheme was not attractive enough to encourage the participation of many farmers. By 1958, fewer than 200 women had joined, cultivating a mere 120 hectares, and the scheme was abandoned in that year.

With support from Taiwan, the development of rice irrigation was resumed in 1966 around the area of Georgetown (30 kilometers upstream from the present survey area). This scheme was designed to assist farmers in establishing their own small perimeters for pump-irrigated double cropping. Inputs, such as fertilizer, seed, and fuel, were provided free for the first year, but farmers were expected to meet all costs themselves in subsequent years. The attraction of free inputs resulted in the development of 1,200 hectares by 1974. Since no support was given to farmers after the first crop, yields and productivity levels declined rapidly. Flooding continued to be a problem because of deficiencies in technical design. Unlined canals leaked and the lifespan of pumps and tractors was short because they were ill-adapted to local conditions.

The Taiwanese mission finally withdrew in 1974 to be replaced by personnel from mainland China. The latter committed themselves to furthering the work that had previously been carried out, using the same methods. However, by 1980, only 500-800 more hectares had been developed, and this scheme was suffering the same problems as its predecessors: mechanical failures, flooding, and declining yields.

Between 1972 and 1977, the World Bank also sponsored a scheme to consolidate the existing Taiwanese irrigation perimeters and to develop a further 1,200 hectares. The main departures of this scheme from the Taiwanese model were the continuous provision of inputs on credit and the establishment of a strict timetable for cultivation activity that farmers were expected to adhere to or be expelled from the scheme. When it was completed in 1977, less than two-thirds of the target area was developed, and countless farmers were falling behind on their loan repayments. By 1982, only 30 percent of the perimeters undertook dry-season irrigation and less than 10 percent attempted a wet-season crop. Nevertheless, some of the World Bank and Taiwanese perimeters continue to survive and to produce mainly wet-season crops. It is these perimeters that are referred to in later text and tables as the "old schemes."

Despite these many setbacks, The Gambia's planners have remained committed to the idea of large-scale irrigation. The latest attempt is the Jahally-Pacharr Smallholder

Rice Project, which is also seen as a pilot scheme to assess potentials for large-scale irrigation that could technically be developed following construction of a barrage that would prevent saltwater intrusion and permit regulation of river water flow in the dry season. Under the leadership of the International Fund for Agricultural Development (IFAD), the project is funded mainly by foreign donors and managed jointly by the Gambian Ministry of Agriculture and outside consultants.

Cost of Rice Production under Various Technologies

It is widely recognized that costs of irrigation schemes in Sub-Saharan Africa are high by Asian and Latin American standards. West African cost figures rank high even within the unfavorable African experience. However, comprehensive comparisons based on analogous calculations are lacking. Rough estimates suggest that new schemes in Africa cost 64 percent more than in the Far East and 55 percent more than in Latin America (FAO 1986, 39-49). This appears to be due to higher input (transportation), staff, and management costs. As the Food and Agriculture Organization of the United Nations (FAO) has underlined, "When all items of a project are added together, they tend to confirm the general statement that irrigation in Africa 'now costs US\$15,000-20,000 per hectare,' provided that the definition of 'irrigation' includes full water control with pump supply on a site requiring a complete range of technical and production support services as well as social infrastructure" (FAO 1986, 42).

The Jahally-Pacharr project is no exception to that general statement. Conservative estimates suggest an investment cost of US\$9,322 and total establishment costs of US\$14,481 per hectare of irrigated land (all types) (Table 3). Investment costs cover

Table 3—Planned investments and running costs during establishment of the Jahally-Pacharr project, 1983-87

Investments/Costs	Share of Total Cost ^a	Cost per Hectare of Irrigated Land at Full Development, 1987 ^b
	(percent)	(US\$) ^c
Investments		
Civil works		
Land development	40.6	
Other	11.2	
Equipment, machinery, vehicles	12.6	
Subtotal	64.4	9,322
Running costs for project establishment		
Fuel	0.5	
Spare parts, maintenance	0.5	
Personnel (including expatriate staff)	22.6	
Subtotal	35.6	5,159
Total	100.0	14,481

Sources: Computed and estimated from Jahally-Pacharr project reports.

^a Expenses for monitoring and evaluation and for social services are excluded.

^b The land is expressed on a "pump-irrigated land equivalent" basis. The land area at full development of the project used for this calculation consists of 560 hectares of pump-irrigated land, 500 hectares of tidal-irrigated land, and 450 hectares of rainfed land. The respective areas are weighted on a yield basis. This results in 991 hectares of "irrigated-land equivalent."

^c U.S. dollars are converted from special drawing rights (SDR) (1 SDR = US\$1.216).

about 64 percent of establishment costs and most of this is for land leveling. While the experience of yields in irrigation projects is not very encouraging in many West African situations, this project stands out with impressive yields of about 5-6 metric tons¹⁴ of paddy per hectare twice a year (from the pump-irrigated and drained and fully water-controlled plots). Project operating costs recently stood at US\$317 per ton (excluding farmers' inputs and labor). As production costs for rice differ substantially by type of production technology, economic cost estimates are presented by technology later after a brief description of the project.

The Jahally-Pacharr project was initiated in 1983. By 1986 it covered 560 hectares of centrally pump-irrigated land, 188 hectares of tidal-irrigated land, and 432 hectares of improved rainfed land. Two crops a year are harvested from the centrally pump-irrigated plots. Only one annual crop is usually harvested from the partly water-controlled land, which is partly tidal-irrigated and partly improved rainfed rice or a mix of the two.

Land in the project is distributed to about 7,500 farmers who cultivate an average of 0.43 hectare of fully water-controlled equivalent land per compound.¹⁵ Farmers repay loans for land preparation, water, seed, and fertilizer charges by selling back part of their produce to the project immediately after harvest.¹⁶ Loan repayments showed an unusually good record in the first few years of project operation, with 92-99 percent recovery, but have declined in recent years, when yields have been lower. The charges to the farmer on a per hectare basis represent 25 percent of the average output per hectare in 1986 and have been adjusted to increased input cost over the years.

Producer prices for project paddy paid by the local cooperative were D945 in 1986.¹⁷ This is equivalent to US\$263 per ton of white rice at a parallel exchange rate (in 1986, US\$1 = D6) and a milling rate of 0.6. The white rice price for consumers in Banjul in 1986 was about D1,793 (US\$299). Rice was taxed both through import restrictions and through a direct tax, which amounted to a 44 percent tax rate for urban consumers in 1986. Between 1977 and 1985, this ranged between a tax of 25 percent and a subsidy of 10 percent, with the average being a 15 percent tax.¹⁸ Thus, during the 1980s, The Gambia was not among those countries that pursued a "cheap food policy" by world market standards.

In the following cost calculations, a distinction is made between fully water-controlled (pump-irrigated) rice in the project that yields two crops a year, partly water-controlled rice in the project that yields one crop a year (tidal-irrigated and rainfed), and swamp rice outside the project. Cost calculations per hectare and per ton of milled rice are broken down by major cost categories and by domestic and foreign exchange costs in Table 4. The analysis is then further developed to include domestic resource cost (DRC) calculations in Table 5.¹⁹

The DRC approach is used to estimate comparative advantage in rice production under alternative technologies vis-à-vis the import option. The DRC is thus the cost in

¹⁴ All tons referred to in this report are metric tons.

¹⁵ For comparative purposes, land in the project is expressed in "fully water-controlled equivalent land" based on the different yield levels.

¹⁶ Cash payments are also possible, but this option has only recently been chosen to a more significant extent by farmers.

¹⁷ D is the currency abbreviation for the Gambian dalasi. In September 1985, US\$1.00 equaled D3.50 at the official exchange rate and D5.06 at the parallel market rate; in June 1987, US\$1.00 equaled D7.50, with little difference between the official and the parallel rates.

¹⁸ For the detailed price and tax calculations based on the parallel exchange rate and taking account of handling costs, see Johm (1988).

¹⁹ On the concept of DRC, see, for instance, Bruno (1972) and Gittinger (1982).

Table 4—Production costs of rice in various technologies, 1985

Position	Share of Foreign Cost (percent)	Production Costs of Jahally-Pacharr Project Rice						Production Costs of Swamp Rice (Single Crop)		
		Fully Water-Controlled Rice (Sum of Double Crop)			Partly Water-Controlled Rice (Single Crop)					
		Total	Domestic	Foreign ^a	Total	Domestic	Foreign	Total	Domestic	Foreign
		(dalasi/hectare)	(dalasi/hectare)	(US\$/hectare)	(dalasi/hectare)	(dalasi/hectare)	(US\$/hectare)	(dalasi/hectare)	(dalasi/hectare)	(US\$/hectare)
Investment costs ^b										
Operation cost (annual)	75	5,370	1,342	796	1,497	373	222	...	...	...
Other variable production cost ^c	90	1,785	179	317	432	43	77	...	...	...
Opportunity cost of unpaid labor ^d	46.25	1,860	1,004	169	527	265	48	160	120	8
Milling and handling ^e	15	1,427	1,213	43	756	643	22	718	610	21
Total cost per hectare	50	937	468	93	286	143	28	121	61	12
Share of equivalent foreign exchange cost in total cost (percent)		11,379	4,206	1,418	3,498	1,487	397	909	791	41
Share of investment cost in total cost (percent)		(63.1)			(57.5)			(20.8)		
Total costs per metric ton (dalasi) ^f		(47.1)			(42.8)			(0.0)		
Total costs per metric ton (US\$)		1,635	604	204	2,082	885	236	1,297	1,027	53
Total costs per metric ton, excluding investment cost (US\$)		323			411			256		
		171			235			256		

Source: Computed and estimated from Jahally-Pacharr project reports.

^a Computed at shadow exchange rate when conversion required (1985: US\$1.00 = 5.06 dalasi).

^b Total investment costs annualized based on 10 percent interest and 30-year repayment period. Fully water-controlled land required investment cost of US\$10,000 per hectare; partly water-controlled, US\$2,792 per hectare.

^c Economic cost for situation with the average sample survey yields (fertilizer, seeds, and so forth); 46 percent refers to "fully water controlled."

^d Using prevailing male and female wage rates in respective seasons (wet season, D3.50; dry season, D1.50). Fifteen percent of the opportunity cost of unpaid labor is specified under foreign cost. This 15 percent is estimated to represent the average share of unpaid labor's opportunity costs accounted for by foreign exchange-earning activities (seasonal groundnut production in neighboring Senegal and other migration-remittance relationships).

^e Based on 10 percent of value of output.

^f Based on mean rice yield (milled rice, metric tons per hectare per year) from sample survey: fully water-controlled rice, 6.96 tons; partly water-controlled rice, 1.68 tons; and swamp rice, 0.77 tons.

Table 5—Domestic resource cost calculations for various rice technologies, 1985/86

Position	Jahally-Pacharr Project Rice		Swamp Rice
	Fully Water-Controlled	Partly Water-Controlled	
	(cost/metric ton of milled rice)		
Domestic production cost (dalasi) ^a	604	885	1,027
Rural marketing (dalasi)	71	71	71
Total domestic production cost (dalasi)	675	956	1,098
Foreign production cost (US\$) ^a	204	236	53
Domestic cost of importing rice into rural market (dalasi)	125	125	125
Foreign cost of importing rice into rural market (US\$) ^b			
100 percent broken (Thai)	195	195	195
5 percent broken (Thai)	288	288	288
Domestic resource cost (DRC) ^c			
100 percent	negative	negative	6.85
5 percent broken	6.55	15.98	4.14
Resource cost ratio			
100 percent broken	negative	negative	1.35
5 percent broken	1.29	3.16	0.82
Critical c.i.f. import price of rice at which DRC would equal shadow exchange rate (US\$1.00 = D5.06)	313	400	245

Source: Calculated from Jahally-Pacharr project records and the 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: The calculations are based on the finding that the rural area of The Gambia is a net importer of rice. This is the case even if appropriate adjustments for border trade are made and is also confirmed by household-level supply and disappearance balances based on the International Food Policy Research Institute/Planning, Programming, and Monitoring Unit survey.

^a For details, see Table 4.

^b C.i.f. price Banjul (US\$187/metric ton of 100 percent broken Thai rice and US\$280/ton of 5 percent broken) plus foreign marketing cost into rural markets of US\$8/ton.

^c The domestic resource cost (DRC) is computed as follows on a per-ton-of-rice basis: $DRC = (Total\ domestic\ production\ cost - domestic\ cost\ of\ importing\ rice\ into\ rural\ market) / (Foreign\ cost\ of\ importing\ rice\ into\ rural\ market - foreign\ production\ cost)$. For example, with the figures for fully water-controlled rice and the 5 percent broken-rice quality: $DRC = 6.55 = (675 - 125) / (288 - 204)$.

domestic currency required to earn one unit of foreign exchange through a project. In economic analysis, a project is deemed successful if the DRC is less than the shadow exchange rate (Gittinger 1982, 398-400, 468). In the case under consideration, the DRC is the ratio of domestic cost of production and the difference between the border price of rice and the foreign exchange content of production and marketing costs:²⁰

$$DRC = \frac{\text{Domestic cost of production in shadow prices per ton}}{(\text{c.i.f. import price per ton} - \text{foreign costs per ton})} \quad (9)$$

Comparative advantage may be measured by the resource cost ratio (RCR) of DRC and the shadow exchange rate (SER) of the currency:

²⁰ As rural Gambia is a net importer of rice, the cost calculations are for a rural market point in the study region in central Gambia.

$$RCR = DRC/SER,$$

(10)

and if

$RCR > 0$ and < 1 , advantage; 1, neutral; and > 1 , disadvantage.

The calculations are made with 1985 prices, assuming sustained yield levels.

The cost of rice production per unit (ton) is higher in the two more advanced irrigation technologies than in swamp rice but decreases for the advanced technologies if investment cost is excluded. The share of foreign cost in total cost increases from 21 to 63 percent when swamp rice is compared with fully water-controlled rice.

The share of investment cost in total cost of the new technologies is 47 percent for fully water-controlled rice and 43 percent for partly water-controlled rice. The high cost of production per unit and the fact that the DRC exceeds the shadow exchange rate result from the high investment costs, which are mainly (75 percent) met from foreign capital.

While almost all of The Gambia's rice imports are 100 percent broken rice (which was available for an average of US\$187 per ton in 1985), the critical import price at which domestic production at current cost structures and exchange rate would be viable is US\$313 per ton in fully water-controlled rice and US\$400 per ton in partly water-controlled rice. Swamp rice production is closer to competitiveness with a critical import price of US\$245 per ton. If the import price of rice were at US\$280 (which was also the 5 percent broken rice price in 1985), the fully water-controlled rice would show a DRC of D6.55—that is, to earn/save US\$1.00, D6.55 is being expended in this technology, which is slightly above the shadow exchange rate of D5.06/US\$1.00 in 1985.

These cost calculations give broad insights into the trade-offs between technologies. Clearly, cost of production has to come down substantially if the partly water-controlled rice technology is to be competitive. Yield potentials also need to be more fully exploited.

Because of a water shortage in the dry season, there is only a limited possibility for further expansion of fully water-controlled rice in The Gambia. Consequently, although almost viable under assumed long-term trends of international rice prices and under optimal project management conditions, this technology cannot hold the key to expanded rice production in The Gambia in the future. The future may be somewhere between the tested partly water-controlled technology (tidal and improved rainfed irrigation) and traditional swamp rice. However, it appears that partly water-controlled rice is not viable as analyzed here, because of large land-leveling and related investment costs. Smaller perimeters that require a lower per hectare leveling cost and still achieve comparable yields appear more competitive. In this context, it should be stressed that the partly water-controlled rice in the project shows a particularly broad spectrum of yield achievements (discussed later in this chapter). The project's function of identifying successful technologies within this setting has therefore been an important one in order to avoid misallocation of resources in future project designs.

The remaining part of this chapter describes and analyzes production relationships at the microlevel and how they are influenced by the new rice project. The analysis comprises, first, an analysis of the adoption of new technology, which in this case means gaining access to land in the project. Second, a quantitative account is given of how the division of land and labor between sexes, and between communal and individual farming, is changed by the new technology. Third, the effects on the output and labor productivity of various groups of farmers and on the crops that they produce are evaluated.

Access to the New Technology

Responsibility for crop production is divided between men and women. Men organize the bulk of upland cereals production, being responsible for more than 90 percent of those fields; women, on the other hand, organize swamp rice production (Gamble 1949, Weil 1973)—more than 90 percent of swamp rice fields are under female control. Both men and women are in charge of organizing traditional cash crop production. Women control close to 40 percent of all groundnut and cotton fields (Table 6), producing 28 and 29 percent of output, respectively.

Access to the new production technology—pump and tidal irrigation, coupled with fertilizer and improved seed—is tied to participation in the project. As project production is closely supervised, the "adoption" of new technology is largely synonymous with getting access to new rice land in the project through a more or less rationed distribution of land to villages, then intravillage to compounds, and finally within compounds to individuals or groups of compound members.

This distribution of the new rice land to farmers in the project poses problems of equity and efficiency. It is an issue of differentiation between villages, between compounds of the same village, and between male and female farmers of various socioeconomic characteristics in the same compound. In the Jahally-Pacharr project an equity-oriented approach to land distribution was attempted, whereby 0.5-hectare plots of land were given out to be shared, usually by compounds of the same village. As many as five compounds or different *sinkiro* groups may share the same 0.5-hectare

Table 6—Control over fields, by sex and male status in the compound, wet season 1985

Crop	Number of Fields in Sample	Fields Under Men's Responsibility		Fields Under Women's Re- sponsibility
		Total	Under Compound Heads	
(percent of all fields)				
Fully water-controlled rice in project ^a	174	90	69	10
Partly water-controlled rice in project ^b	103	23	22	77
Pump-irrigated rice in old schemes ^c	28	32	21	68
Swamp rice	302	9	2	91
Total	607	36	26	64
Early millet	302	91	53	7
Late millet	17	94	59	6
Sorghum	65	98	72	2
Maize	214	98	70	2
Total	598	95	62	5
Groundnuts	636	61	22	39
Cotton	83	63	22	37
Total	719	61	22	39
All crops	1,924	63	35	37
All crops, excluding rice projects	1,619	64	33	36

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

plot and subdivide it. Land was distributed across a wide range of villages, some of which were inhabited by traditional rice farmers located close to the project, and others, farther away from the site, whose farmers had not been involved in rice farming before.

Land distribution criteria laid down at the outset stressed that priority access to project land would be accorded to traditional rice-cultivating villages (lowland villages that were much involved in swamp rice production before the project) and especially to women (Altarelli-Herzog 1983, 1984). Land allocation committees were set up to distribute quotas of plots to villages wishing to participate. At the village level, distribution committees were to organize the final distribution to compounds and individuals. In the event, different procedures were adopted by the project and consequently different patterns of distribution emerged. The final distribution at village level was handled very differently from village to village, depending on committee organization, the position of women in respective ethnic groups, and so forth. Thus the outcome of the distribution process poses important research questions that are more fundamental than simply whether administrative procedures were actually adhered to or not.

On average, 0.43 hectare was allocated per household unit (compound).²¹ Equality of distribution varies considerably between villages (Appendix, Table 57) and within villages.

A more refined approach is used to assess the main determinants that shaped the final outcome of the land distribution. First, the characteristics of compounds that succeeded in obtaining more versus less of the project rice land are analyzed. Second, the factors that determined the probability of individual women gaining access to project land, and thus to the new production technology, are analyzed (see models shown in equations [1] and [2] in Chapter 2).

The first approach uses a regression model in which the amount of land per compound is the dependent variable. It was hypothesized that the size of a compound, its location in an upland or lowland village, and long-term residency and ethnicity affected the distributional outcome. Also, a test was conducted if compounds that had more land and farm capital endowments before the project had more access than others. Results of the multivariate analysis on compound-level distribution are presented in Table 7. The results suggest that the pattern of access does not fit a simple rich/poor or small farm/large farm distribution. All else remaining the same,

- Upland village compounds obtained 0.30 hectare less than those in lowland villages (variable 3), holding compound size constant (variables 1 and 2).

- Larger compounds (with larger work forces) obtained more land but at a decreasing rate (variables 1 and 2). Thus smaller units fared better on a per capita basis.²²

- Mandinka compounds, traditionally more involved in rice production (by women), obtained significantly more access than all other ethnic groups (Wolof and Fula access is not significantly different from that of Serahuli) (variables 8, 9, and 10).

- Compounds that settled in the village longer than 10 years ago received on average 0.09 hectare more than their younger counterparts (variable 4). Higher status, which is usually related to compound age, affected project access significantly.

- Farm size and capital stock before the project did not significantly affect project access. There is thus no indication that the better-endowed compounds got significantly more access to the new technology (variables 5, 6, and 7).

²¹ This area is expressed in terms of "fully water-controlled land equivalents," meaning that all rainfed and tidal-irrigated fields are converted on a yield-per-hectare basis to fully water-controlled land.

²² For aggregate comparisons, persons are aggregated to adult-equivalent units on the basis of FAO-recommended calorie requirements: men = 1.00, women = 0.85, male 10-14 = 0.95, female 10-14 = 0.83, children 5-9 = 0.81, children 0-4 = 0.52.

Table 7—Determinants of access to land in the rice project, by compound (multivariate analysis)

Explanatory Variable	Parameter	t-Value
(1) Size of compound in adult-equivalent persons	0.0314	5.72
(2) Size of compound in adult-equivalent persons squared	-1.6024E-4	-1.73
(3) Upland villages (= 1, else = 0)	-0.2963	-4.32
(4) Long-term resident (compound older than 10 years)	0.0904	2.21
(5) Before-project farm size per adult-equivalent person	-0.0291	-0.17
(6) Before-project farm size per adult-equivalent person squared	0.0514	0.50
(7) Before-project farm capital per adult-equivalent person	6.4942E-4	0.64
(8) Mandinka	0.2661	2.86
(9) Wolof	-0.0658	-0.56
(10) Fula	0.0543	0.53
Constant	0.0144	
R ²	0.718	
F-value	38.77	
Degrees of freedom	138	

Note: Dependent variable—amount of rice land in the project per compound in hectares (in fully water-controlled land equivalent).

The project's land-distribution policy was specifically aimed at ensuring women's access to the project rice land. Women were given land titles (long-term leases) in a formal registration process. To what extent this process translated into women's de facto control over land, and the right to cultivate it as their own *kamangyango* (personal) fields, was assessed separately. Results are taken from a random sample of women who reported having worked in the project fields in 1985/86. The results show that 52 percent of the women reported that they are *registered* as being responsible for a piece of project land. However, only half of those women actually control a field or are able to share one with other women. On the other hand, 29 percent of *unregistered* women have access to fields, mainly by sharing. Thus a total of 40 percent of the women in the sample ended up with a piece of land under their control. Nearly all of these fields are of the lower-yielding tidal-irrigated or rainfed type; only 10 percent of fully water-controlled fields are under female control, compared with 77 percent of the tidal/rainfed fields (Table 6). Most of the surveyed women (87 percent)—whether registered or not—work in the communal project fields.

The question of what determined women's access, or nonaccess, to the new rice fields is addressed next. A probit model is used to assess the factors that enhanced or reduced the probability of women's access to project rice fields. The dependent variable in the model is 1 or 0 (1 if a female farmer in the sample has her own rice field in the project). The qualitative response model is estimated, using Newton's method—that is, the variance matrix for the coefficients is estimated with the second derivatives of the log-likelihood.²³ There are 463 women included in this analysis. The model hypothesizes that women's access to new technology is determined by the socioeconomic and lineage characteristics of their compound and by their own individual status within the compound. The results of this analysis (see Table 8) are as follows:

- Women of higher status, that is, older women and *sinkiro* heads (who are usually first wives of compound heads), had a significantly higher probability of obtaining a field (variables 1, 2, and 3, Table 8).

²³ The program LIMDEP was used for estimation; see Greene (1986, 19.3-19.10) and Maddala (1983).

Table 8—Determinants of access of individual women to fields in the project (probit estimate)

Explanatory Variable	Estimated Parameter	t-Value	Change in Probability of Having Access to Field ^a
(1) Age of women ^b	-0.9847E-1	-8.39	-0.039
(2) Age of women squared	0.1232E-2	6.81	+0.005
(3) Woman is <i>sinkiro</i> head	0.8733	4.82	+0.350
(4) Woman is married to compound head	0.1471	0.78	...
(5) Woman was traditional rice grower ^c	0.4827	2.64	-0.200
(6) Number of women in compound ^d	-0.3610E-2	-2.52	-0.001
(7) Compound has more than one <i>sinkiro</i>	-0.1703	-0.95	...
(8) Size of land in project for whole compound ^e	0.7353	3.99	+0.290
Number of observations	463	...	...
Chi-squared	40.02	...	...

Note: Dependent variable—if a woman had her own field in the project or shared one with other women (= 1, else = 0).

^a The probability is approximated from the estimated parameter by multiplying with the factor of 0.4 following an approximation approach described in Takeshi Amemiya, "Qualitative Response Models: A Survey," *Journal of Economic Literature* 19 (December 1981): 1483-1536.

^b Age in years.

^c Dummy variable = 1, if a woman had her own rice field in the area before the project and a personal rice store.

^d Number of women of working age in the compound.

^e Amount of project rice land in hectares expressed in irrigated land equivalent (for the whole compound).

• Traditional rice growers, defined as having had both a field and a personal rice store before the project, also had a significantly increased probability of obtaining a field (by 22 percent, variable 5); thus, traditional rice-growing women were protected to a certain extent by the distribution.

• Land allocation was carried out to the relative disadvantage of women in large compounds inhabited by many women (variable 6).

• The greater the amount of project land allocated to a compound, the higher is the probability of a woman in that compound gaining access to some of that land (variable 8).

To sum up this section, access to new rice land was widely distributed across the communities in the project region. At compound level, no apparent maldistribution by preproject resource endowments occurred. Ethnicity played a role in gaining access, partly as a result of different specializations of ethnic groups in economic activities and within agriculture. Contrary to the intent of the project, women were not the primary beneficiaries of the fully water-controlled land, but they did gain access to the partly water-controlled land. Among women alone, status characteristics were important in determining access to the improved rice land.

Technology Levels, Yields, and Control Over Cro

Much of the rice land in the Jahally-Pacharr project is used for growing a communal (household) crop. This is true for nearly all of the fully water-controlled land and for a substantial share of the tidal and rainfed plots (Table 9). The traditional upland cereals are also largely grown as communal (*maruo*) crops, while most of the cash crops (groundnuts and cotton) and swamp rice are grown as private (*kamangyango*) crops. Each upland communal field is under the responsibility of a man (usually the compound head), while the communal rice crop is customarily controlled by a woman.

Table 9—Use of communal and private fields in sample compounds, by crop and technology, wet season 1985

Crop	Overall Share of Land Use	Communal (Maruo)	Private (Kamangyango)		
			Total	Men	Women
	(percent)		(percent of hectares of crop)		
Fully water-controlled rice in project ^a	5.8	99.0	1.0	1.0	...
Partly water-controlled rice in project ^b	4.1	87.0	13.0	3.0	10.0
Pump-irrigated rice in old schemes ^c	0.5	67.0	33.0	...	33.0
Swamp rice	10.7	17.0	83.0	6.0	77.0
Early millet	23.1	82.0	18.0	14.0	4.0
Late millet	1.1	81.0	19.0	14.0	5.0
Sorghum	4.2	88.0	12.0	12.0	...
Maize	9.1	92.0	8.0	8.0	...
Groundnuts	37.0	18.0	82.0	59.0	23.0
Cotton	4.5	15.0	85.0	59.0	26.0
All crops	100.0 ^d	51.0	49.0	30.0	19.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^d Parts do not add to total because of rounding.

Women's control over rice fields declines according to yield (technology) levels in the various types of rice production (Table 10). This changing pattern of female responsibility for rice is, however, not simply a switch from a "women's crop" to a "men's crop," but a switch from a mixed communal food/private cash crop, grown mainly by women, to an almost purely communal crop under the responsibility of the (male) compound head.

A close look at the few cases ($n = 17$) of women who actually got access to fully water-controlled rice reveals that these are special cases. One woman is the wife of a

Table 10—Wet season yield levels and female control of rice fields, by technology, 1984 and 1985

Technology	Average Yield		Fields Under Control of Women	
	1984	1985	1984	1985
	(metric tons/hectare)		(percent)	
Fully water-controlled rice in project ^a	6.6	5.2	14	10
Pump-irrigated rice in old schemes ^b	2.9	2.4	54	68
Partly water-controlled rice in project ^c	2.2	2.8	70	77
Swamp rice	1.3	1.3	95	91

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

compound head who is a blacksmith, another's husband is a dry fish trader, a third is the wife of a shopkeeper. In some cases the compound head is rather old or unable to work or has recently passed away and the new compound head is a young boy, and in others the compound head is absent for an extended time. In all of these cases, the fully water-controlled land in the project is used by the senior women as communal land. This occurs even when the same women formerly cultivated their swamp rice as *kamangyango*. The project land thus serves to provide the staple food for consumption in these compounds. The rice crop from the fully water-controlled fields (which provide the highest yield per unit of land) is the one that is most completely transformed into a communal crop (99 percent, Table 9). The relative security of production from these fields and the drought conditions in the area in 1983-85 are important determinants of this.

Yet, while cross-sectional variation of the yields of this rice crop was low (0.27 in 1985, Table 11), yields in the rice perimeter with full water control (pump irrigation) do not appear stable over time. From 1984 to 1985, average yields in the wet season dropped from 6.6 to 5.2 tons, and a reduction occurred also in the 1986 dry season

Table 11—Yields of major crops and variances of yields in the sample, by season, 1984-86

Crop	Yield ^a			
	Wet Season		Dry Season	
	1984	1985	1985	1986
	(kilograms/hectare)			
Fully water controlled rice in project ^b	6,552 (0.24)	5,171 (0.27)	6,488 (0.27)	5,072 ^c
Partly water-controlled rice in project ^d	2,187 (0.73)	2,797 (0.54)	...	...
Pump-irrigated rice in old schemes ^e	2,862 (1.03)	2,362 (0.97)	2,471 (0.59)	...
Swamp rice	1,274 (0.77)	1,277 (0.77)	...	...
Early millet	855 (0.82)	1,103 (0.80)	...	...
Late millet	760 (1.16)	1,127 (1.14)	...	...
Sorghum	197 (1.17)	259 (0.92)	...	...
Maize	402 (1.56)	616 (1.16)	...	...
Groundnuts	1,244 (0.73)	1,214 (0.65)	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Numbers in parentheses represent coefficients of variation.

^a The yields are from fields harvested; yields per hectare of land sown are less in the case of upland cereals and groundnuts, especially in 1984, due to drought effects.

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c Based on a subsample of only 10 percent of households.

^d These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^e These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

(1986 dry-season data are based on a subsample only). The reduction in yields in the wet season is apparently a consequence of increased competition for scarce labor in upland crops. This issue will be addressed below.

Effects of Project on Labor in Subsistence and Cash Crops

Given the average input of 349 person days per hectare per season, the pump-irrigated fields in the fully water-controlled part of the project require 61 percent more labor per hectare than does swamp rice (Table 12). This is the case even though many of the necessary land preparation activities are centrally provided to farmers by the project. Hired labor, usually paid in cash, makes up a substantial share (25 percent) of the total labor input to fully water-controlled fields and 11 percent of the labor input to partly water-controlled fields. Among other crops, 9 percent of the labor input for cotton production is met by hired labor, 6 percent for groundnuts, and 2-3 percent for upland cereals. The recent expansion of the market for hired labor in rice, which hardly existed before, is clearly associated with the new project.

A central question frequently asked is, "To what extent is the shift between men and women in responsibility for crops (fields) also reflected in a transfer of labor between crops?" Or, more specifically, "Do women now perform much of the work on the male-controlled communal rice fields, whereas before they were working for income or food under their own control in their individual rice fields?" In answer to the first question, the share of women's labor in total family labor for the four different rice technologies generally follows the pattern observed for responsibility over fields. Therefore, the answer to the second question is generally no. In swamp rice, where women are responsible for 91 percent of fields, they provided 77 percent of the family

Table 12—Hired and family labor input per hectare, by crop and technology, wet season 1985

Crop	Total Labor	Total Hired Labor	Total Family Labor ^a	Family Labor ^a		
				Men	Women	Children
				(percent of family labor)		
	(person-days/ hectare)	(percent of total labor)		(percent of family labor)		
Fully water-controlled rice in project ^b	349	25	75	69	29	2
Partly water-controlled rice in project ^c	262	11	89	39	60	1
Pump-irrigated rice in old schemes ^d	377	7	93	24	68	8
Swamp rice	217	5	95	17	77	6
Early millet	95	3	97	83	10	7
Late millet	84	2	98	91	3	6
Sorghum	87	3	97	95	1	4
Maize	90	3	97	80	9	11
Groundnuts	141	6	94	69	26	5
Cotton	132	9	91	57	39	4
Total average	...	7	93	62	32	6

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Strange Farmers are included in family labor, since they are not paid in cash and reside within the compounds for an extended period.

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^d These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

labor in 1985. In the fully water-controlled fields of the project, of which women control 10 percent, they provided 29 percent of the family labor input (Table 12). The two other types of rice technologies range between these two extremes.

The close correlation between responsibility for crop production and labor input by sex for that crop also appears in the upland crops. Women do little work in the upland cereals when they are not responsible for them, and their input into groundnuts and cotton is about the same as the corresponding share of land under their responsibility. For instance, women provide 26 percent of all family labor in groundnuts, and their fields cover 27 percent of the total groundnut area in the sample.

In the wider picture of division of labor, women provide 32 percent of all family labor in this sample for the major field crops and men provide 62 percent (Table 12). Although general discussions frequently assume higher figures for women's labor in agriculture in Africa, this finding is in line with results from other detailed studies on women's labor input in West African agriculture.²⁴

Earlier research on rice in this location, with less coverage of ethnic groups and agroecological settings, found much rigidity of sexual division of labor by crop (Dey 1982). The present study indicates that the men provide 17 percent of all family labor to swamp rice production, which is almost exclusively a women's crop. At the same time, women are responsible for 29 percent of all private groundnut and cotton production, and men also provide considerable amounts of labor on these private upland fields.

With regard to ethnic differences, there are indeed substantial differences within this sample. In the upland villages, the Fula and Wolof ethnic groups predominate, while Mandinka and Serahuli are the majority groups in the lowland villages. Upland villages, which are farther away from the new rice land, use more hired labor in their project fields (29 percent), and very little of the project work is done by women (8 percent). Women from these villages, who are not traditional rice farmers, work to a greater extent in upland cereals (15 percent) and in groundnuts (34 percent).

There exists a fair amount of labor-sharing between women and men. Twenty-four percent of the work in the fully water-controlled fields that are under male control is accounted for by hired labor; the remaining 76 percent is family labor, of which 26 percent is provided by women. The few women who are responsible for a rice field of this type use more hired labor (35 percent) and provide more of the total family labor to such fields themselves (51 percent). In Table 13 the division of labor is presented for all fields separately by communal and individual organization. In general, it is found that when a field is under communal organization and controlled by a man (usually the compound head), most of the family labor input comes from men. This is least pronounced in the case of partly water-controlled rice, which is generally more of a "women's crop." But apart from this case, men contribute 72-86 percent of family labor in the communal fields that are male-controlled. In general, this pattern holds true also for communal fields controlled by women. Here women provide most of the field labor, but with the exception of traditional rice, this pattern is not so pronounced as in the case of male-controlled communal fields.

A fair amount of labor-sharing occurs in individual fields controlled by women, especially in the cash crops—groundnuts and cotton. Women receive a substantial share of family labor input from men in their own mostly private (*kamangyango*) fields. In women's own groundnut fields, for instance, women provide 48 percent of the family labor, while 47 percent comes from men, who are usually their husbands.

²⁴ For a review and a more specific evaluation of this issue, see von Braun and Webb (1989).

Table 13—Division of labor between men and women in communal and individual farming, by crop, wet season 1985

Crop	Organization	Share of Family Labor ^a					
		Fields Controlled by Men			Fields Controlled by Women		
		Number in Sample	Men	Women	Number in Sample	Men	Women
			(percent)			(percent)	
Fully water-controlled rice in project ^b	Communal	155	72	26	18	44	51
	Individual	...	...	...	...	...	...
Partly water-controlled rice in project ^c	Communal	23	62	37	61	29	70
	Individual	...	...	...	16	40	59
Swamp rice	Communal	...	...	...	30	4	86
	Individual	24	58	38	245	14	80
Early millet	Communal	209	86	8	...	...	...
	Individual	67	86	5	22	56	40
Groundnuts	Communal	79	86	7	...	...	...
	Individual	308	82	13	241	47	48
Cotton	Communal	...	...	...	...	...	...
	Individual	43	73	22	27	27	71

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a The child labor share is not listed, so respective figures do not add up to 100. Cases with less than 10 observations in the sample are not listed.

^b These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

The next question to be addressed is, "What is the total agricultural workload of men and women farmers and how did it change under the new rice project?" The marked seasonality of rainfed agriculture does not permit continuous work in the fields. Of total available workdays—about 165 days over the entire wet season—men spend 70 percent and women 36 percent in field crop production (including related preparation and transportation activities). In the dry season, men spend 24 percent and women 13 percent of available time in irrigated rice work. Overall, men in lowland villages of the project area spend a lower share of their time in crop production than men in upland villages (62 percent versus 84 percent in the wet season), but the opposite is true for women (39 percent in the lowland versus 32 percent in the upland villages). Women's work in rice is a main factor in determining this difference. Yet, although labor allocation differs widely by crop between upland and lowland villages and between men and women, the total time spent in agriculture is similar—52 and 57 percent, respectively, of available time in the wet season. It should be stressed that during the wet season there are various labor peaks, especially at times of upland crop weeding and rice transplanting.

The new rice project provides additional employment, particularly in the dry season when there is underemployment, and it induces a substitution effect between work on other crops and work on the new rice fields during the wet season. This is demonstrated in Table 14, where households are grouped by the amount of new rice land available per adult-equivalent person. In the dry season, women and men in the lowest quartile spend 3 percent and 11 percent, respectively, of their time in agriculture, while in the highest quartile they spend 24 percent and 36 percent, respectively.

Table 14—Allocation of men's and women's labor to major crops, by amount of project land cropped per household, 1985

Amount of Land in Rice Project ^a	Time Spent on Crop as Share of Total Available Labor Time in Season				Total
	Dry Season	Wet Season			
		Rice	Millet and Maize	Groundnuts and Cotton	
(percent)					
Men					
Lowest quartile	11	7	31	39	77
Second quartile	19	18	30	32	80
Third quartile	27	23	21	23	67
Highest quartile	36	29	16	13	58
Average (all men)	24	17	25	28	70
Women					
Lowest quartile	3	9	6	19	33
Second quartile	8	25	4	12	40
Third quartile	15	27	1	7	36
Highest quartile	24	33	...	4	38
Average (all women)	13	23	3	11	36

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

^a The quartiles are formed on the basis of amount of land per capita in "irrigated land equivalent area" (area is weighted based on yields in the different technologies in the project area). Mean yields are used as constant weights, so are not influenced by variations in plot-specific land quality (drainage) and input levels.

With increased availability of project rice land, wet season work patterns by men and women show strikingly different tendencies. Men's total work in agriculture decreases from 77 percent to 58 percent of available time (from 127 to 96 days), while women's total work increases slightly (Table 14, last column). This may point to a "leisure" effect for men, or to increased nonfarm work, which is apparently not shared with women. This question is addressed later in a more refined analysis of the reallocation of labor between crops.

It appears that the expansion of men's labor in rice (Table 14, column 2), which results in higher absolute returns per day of work for this communal crop, is accompanied by a higher absolute reduction in labor inputs to the upland crops than in the case of women (Table 14, columns 3 and 4).

The substitution effects between new rice fields and upland crops and swamp rice in an environment of land surplus (in the upland and swamp areas) are mediated through the competition between crops for scarce labor. However, this competition is also reflected in the resultant land-use patterns. In order to assess this, it was possible to draw on longitudinal information obtained in careful recall surveys on a field-by-field basis with the survey farmers. The aggregate results show that total land area cultivated, including the new rice fields, expanded from 1983 to 1985 (the 1984 area increased by 6 percent over 1983 and in 1985 the area was 3 percent larger than in 1983). The area under all other crops dropped by 8 percent (Table 15). In general, this is due to the reduced upland crop production (-10 percent of area) rather than reduced traditional rice production, which declined only for an intermediate year but actually rose again in 1985. As one would expect, those compounds that received large pieces of land in the project most reduced the area of upland crop and swamp rice that they cultivated between 1983 and 1985 (by 27 percent). Conversely, compounds in the lowest quartile (of rice land per adult equivalent) actually expanded the land under all nonproject crops by 7 percent in the same period.

Table 15—Changes in land use by sample households under the new project, by amount of rice land cropped, 1983-85

Household Quartiles of Project Rice Land per Adult-Equivalent Person	Area of Upland Crops and Traditional Rice			
	Hectares in Whole Sample	Index 1983 = 100		
		1983	1984	1985
Lowest quartile	283	100	108	107
Second quartile	216	100	97	93
Third quartile	185	100	88	81
Highest quartile	110	100	74	73
Total	794	100	96	92

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Production Organization and Profitability of Different Technologies

Obviously, there is an opportunity cost for the labor pulled away from the upland crops and swamp rice into the new rice fields. If the difference between the opportunity cost of labor established by the net returns to wet-season upland work and actual net returns to the new fields is small, the net benefit to participants and society will be small (as long as the land-abundant situation prevails in the area). To address this critical issue, a gross margin calculation is performed on a field-by-field basis for the whole sample for all major crops. Gross margin refers to the output product multiplied by the sales price (if nothing was sold, the village-specific average market price for that commodity was used) minus all variable input costs, including seed, fertilizer, hired labor, and other inputs such as charges for water and tractor-powered land preparation in the rice project. The gross margins are then related to unpaid (family) labor and to field size. Mean values of the computations and their coefficients of variation are presented for all major crops in Table 16. It should be noted that these are private returns, not economic (social) returns. The rice production in the project includes a substantial subsidy element, as discussed in Chapter 3.

The average labor productivity in the fully water-controlled rice fields is by far the highest, at D14.70 per person-day. This rice technology requires about 15 times the variable cost per hectare compared with swamp rice and about three times the variable cost per ton of paddy. The need for financing these variable costs is clearly substantial. A credit facility operating in the project provides financing for fertilizer, seeds, and irrigation. But other costs for transport, hired labor when required, and threshing may be significant, too. On average, the other rice types were less remunerative in 1985 than the traditional upland crops (millet/sorghum and groundnuts). In the partly water-controlled fields, mainly operated by women, labor productivity was only half of that in the fully water-controlled fields, but still 30 percent higher than in swamp rice. It should be noted that returns to labor in upland crops were curtailed in 1985 by an unusual fertilizer shortage in The Gambia that affected the upland crops and traditional rice of the sample farmers but did not affect the rice in the project (von Braun and Puetz 1987). Returns to labor in the upland crops were, therefore, rather below the level of a "normal" year.

A compound head who was able to switch his work force from millet/sorghum production for the common food stock to rice in the fully water-controlled section of

Table 16—Farm-level profitability of rice technologies and major field crops, wet season 1985

Crop/Technology	Average Gross Margins ^a and Their Coefficients of Variation ^b		Variable Costs per Hectare
	Per Person-Day of Family Labor	Per Hectare	
		(dalasi) ^b	
Fully water-controlled rice in project ^c	14.7 (0.87)	2,938 (0.46)	1,766
Partly water-controlled rice in project ^d	7.4 (0.96)	1,371 (0.72)	925
Pump-irrigated rice in old schemes ^e	3.8 (1.48)	1,720 (1.20)	538
Swamp rice	5.7 (0.75)	1,041 (0.81)	122
Millet, sorghum	9.0 (0.89)	731 (0.97)	45
Maize	6.6 (1.30)	495 (1.29)	50
Groundnuts	8.7 (0.87)	943 (0.77)	266
Cotton	3.2 (1.38)	375 (1.47)	92

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

^b Coefficients of variation are in parentheses.

^c These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^d These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^e These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

the project gained D5.70 per workday per person of his work force (D14.70-D9.00). In other words, the communal work force needed to work 39 percent less to obtain a similar return (D5.70/D14.70).

Returns to labor in men's fields are higher than in women's fields. This holds true for the individual crops (groundnuts, cotton, and swamp rice) where both men and women have control, and also for the different technology levels in rice (Table 17). The returns to labor in women's fields (partly water-controlled) are 44 percent below men's (fully water-controlled): 39 percent below men's for swamp rice, 35 percent below for groundnuts, and 49 percent below for cotton. An explanation for these consistent differences requires careful consideration of the input and output side of women's field operations. Lower average labor productivity for women is suggested by women's multiple work load in home activities (with the related organizational problem of timeliness in field operations such as preparation and weeding), reduced ability to make decisions on labor allocations within the household and establish a reliable and enforceable labor-sharing arrangement, and reduced benefits from related scale economies. For instance, women's individual groundnut fields are 50 percent smaller than men's. Unproductive walking time to the fields is, therefore, twice as high per

Table 17—Gross margins per person-day in fields under male control and under female control, wet season 1985

Crop/Technology	Average Gross Margin per Person-Day	
	Men's Fields	Women's Fields
	(dalasi)	
Fully water-controlled rice in project ^a	13.9	b
Partly water-controlled rice in project ^c	b	7.8
Swamp rice	8.9	5.4
Millet, sorghum	9.1	8.0
Maize	6.7	b
Groundnuts	10.0	6.5
Cotton	3.9	2.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b Less than 25 observations and therefore not shown.

^c These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

unit of output in women's fields at same yield levels. Women's swamp rice fields tend to be located far from the compound, which results in a high share of working time spent traveling to and from the field. Also, women own far fewer labor-saving implements than men (Table 18). This may be a critical factor in timely use of implements and in breaking labor bottlenecks at times of planting and weeding.

Although the average returns to labor in the fully water-controlled rice in the project substantially exceed the average returns to all other crops, it must be recognized that a substantial number of farmers manage to achieve similar productivity levels in upland crops (see Figure 5). The average return of about D15 per day for fully water-controlled rice is achieved, or even exceeded, by 23 percent of farmers with upland cereals and 17 percent of farmers with groundnuts. The majority of groundnut and millet farmers exceed the average returns per labor day achieved by farmers in the partly water-controlled rice fields of the project.

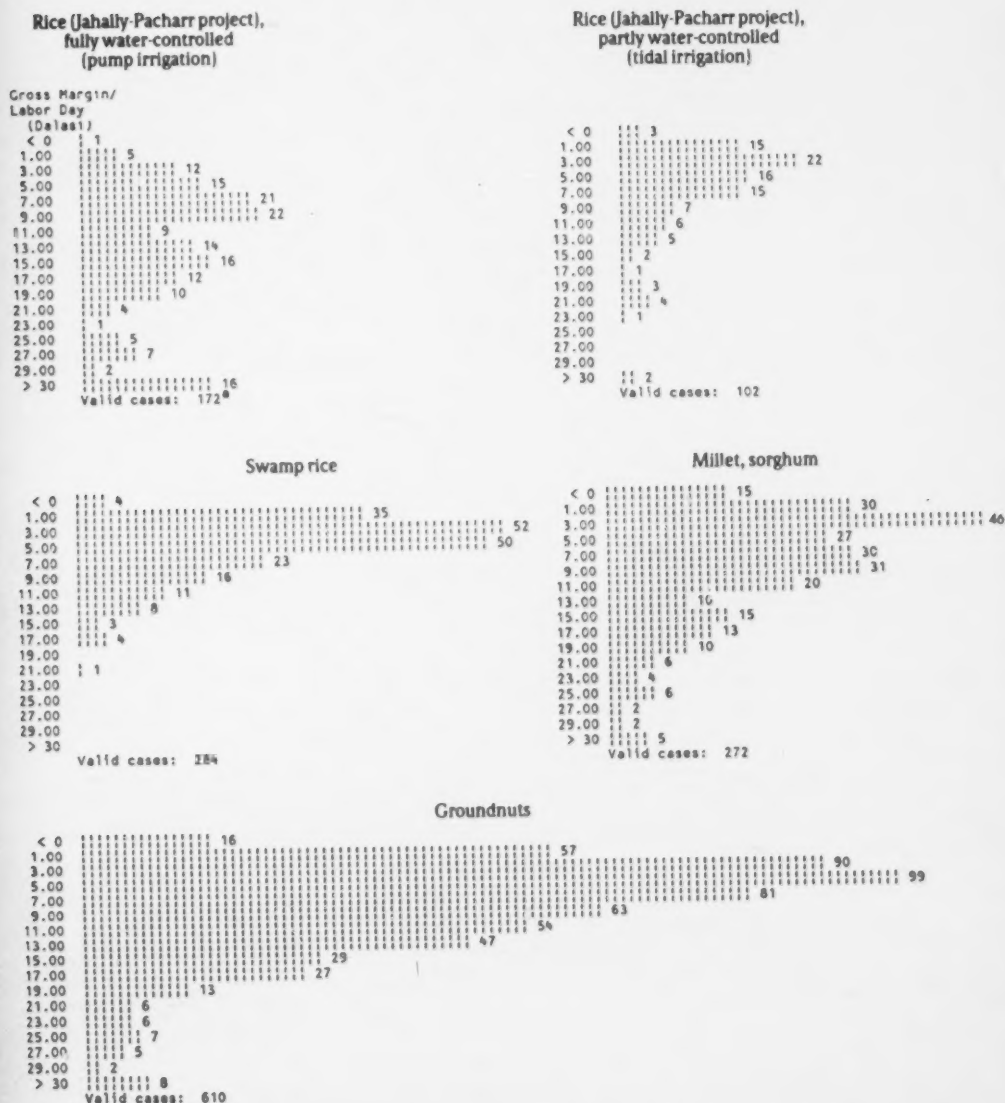
Table 18—Ownership of labor-saving implements by men and women farmers, wet season 1987

Implement	Men	Women
	(percent owning the tool)	
Plow	8.2	0.0
Seeder	26.9	0.6
Weeder	12.4	0.2
Multipurpose implement ^a	18.1	0.4

Source: 1987/88 follow-up survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a An animal-drawn implement convertible for plowing, weeding, and groundnut lifting.

Figure 5—Distributions of returns to labor, by crop, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Cases refer to number of farmers (male and female).

Labor Productivity in New Rice and Traditional Crops

The purpose of the following analysis is to assess the total and marginal opportunity costs of the new rice crops as established by the returns to labor that would otherwise have remained in upland crop and swamp rice production. An assessment is then made of the effects of labor reallocation on food production, manifest in the additional project rice output, which has supplanted a certain amount of production in the upland cereals, upland cash crops, and swamp rice because of competition with labor.

Production Functions

Production functions are estimated to evaluate marginal labor productivity in the various crops. The reallocation of labor induced by the labor demand from the new rice fields is analyzed with the help of labor input functions thereafter (see also conceptual framework in Chapter 2, equations [3] and [4]).

The production functions are specified for main field crops and take the institutional setting, such as communal versus individual field and field under male versus female control, into account and are quadratic in the main inputs to permit decreasing marginal returns.

A note of caution is in order here regarding the general problem of estimating technical input-output relationships on the basis of cross-sectional farm-survey data that are not structured for a strictly controlled experiment. Capturing the factors of variability in managerial skills and in agroecological microconditions poses a particular problem of latent unobserved variables. An attempt was made to take account of these by including variables depicting crop responsibility along gender lines, distance of field from village (the closer ones among upland villages tend to get more manure from grazing animals), and the somewhat better soil conditions in a particular zone among the upland villages along the border to Senegal. The main differences in agroecological conditions are taken into account by separately specifying the production function for the upland areas (soils of sandy detrital sediment of relatively low fertility) and for the lowland areas (hydromorphic soils).

While the main purpose of the production function estimates is to arrive at marginal labor productivity, the authors also want to assess the effects of crop-specific implement use and institutional setting (communal fields, share of fields under women's control) on output. The dependent variable is the total production of the respective crops from communal and individual farming per compound (or compound subunit in the case of some large Wolof and Mandinka compounds) in the wet season of 1985. Slightly modified for the various crops, the production functions have the following formula:

$$Q_{ji} = f[\text{FSIZE}_{ji}, \text{LAB}_{ji}, (\text{LAB}_{ji})^2, \text{FER}_{ji}, (\text{FER}_{ji})^2, \text{TECH}_{ji}, \text{INST}_{ji}, \text{SOIL}_{ji}], \quad (11)$$

where

Q_{ji} = production of crop j on farm i ,

FSIZE_{ji} = size of field(s) in hectares,

LAB_{ji} = total labor input in person-days (paid and unpaid labor) per hectare,

FER_{ji} = fertilizer use per hectare,

TECH_{ji} = set of dummy variables on implements used (see Table 19 for specifics),

INST_{ij} = set of institutional variables (such as communal field, women's fields; see Table 19 for specifics), and

SOIL_{ij} = soil dummy variable for better soils in border zone within upland area.

The estimation results are presented in Table 19. The results are largely consistent with expectations.

Table 19—Production functions of major field crops

Variable ^a	Upland Cereals—Millet, Sorghum, Maize		Groundnuts		Partly Water-Controlled Project Rice and Swamp Rice ^b	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
HAFERT	7.2962	1.54	7.5200	1.97	1.0208	0.29
HAFERTSQ	9.1866E-3	-0.29	-0.0272	-1.18	-1.29542E-0	-0.10
HALAB	10.2583	2.19	7.2779	2.04	8.9287	3.23
HALABSQ	-0.0189	-1.20	-0.0109	-1.28	-0.0127	-2.56
WRKWOMAE	-431.3700	-0.68	-1,113.5900	-1.89	1,210.2085	1.73
MARUOSH	198.4560	0.53	117.0740	0.59	-299.3296	-1.20
WOMENSH	827.9140	1.31	-462.1430	-1.39	304.7832	0.97
SIZEFLD	983.0190	14.78	1,193.1750	23.20	1,545.7655	19.55
DISTANCE	-5.2980	-0.69	1.0661	0.27	-3.1940	-0.68
SINEUSE	173.2760	0.93	-165.4460	2.69	...	...
PLWUSE	-173.9970	-0.95	-829.6420	-1.03	...	...
SOIL	1,021.1590	4.70	441.0320	2.18	...	...
JPSHARE	...	...	...	...	1,392.1316	4.39
Constant	-1,389.2570	-2.54	-723.0742	-1.93	-2,093.7082	-3.38
R ²	0.671		0.821		0.796	
F-value	34.39		72.62		45.59	
Degrees of freedom	184		175		117	

Note: Dependent variables—output of crops per compound, or compound subunit in the case of large Wolof and Mandinka compounds.

^a Definitions of variables in the production function:

- HAFERT = fertilizer applied per hectare in kilograms of material;
- HAFERTSQ = HAFERT squared;
- HALAB = total labor input in person-days per hectare;
- HALABSQ = HALAB squared;
- WRKWOMAE = number of women in household of working age per adult equivalents;
- MARUOSH = share of fields of the crop under communal production (*maruo*);
- WOMENSH = share of fields of the crop under women's control;
- SIZEFLD = size of crop area in hectares;
- DISTANCE = walking distance to field in minutes;
- SINEUSE = multipurpose implement used (= 1, else = 0);
- PLWUSE = plow used (= 1, else = 0);
- SOIL = soil quality dummy within upland area (= 1 if fields close to border area [better soils], else = 0); and
- JPSHARE = share of partly water-controlled land in project over total of tidal, rainfed, and traditional rice.

^b As fully water-controlled rice production in the project does not involve the crop-specific area allocation choice (because of the rationed land distribution), a yield function was estimated for fully water-controlled project rice. Specification and estimation results are as follows:

$$\text{YIELD} = 3,992.9 + 7.1197 \text{ HAFERT} - 0.0124 \text{ HAFERTSQ} + 2.5229 \text{ HALABWE} + 716.23 \text{ SIZEFLD},$$

(8.03)(1.96) (-1.83) (0.74) (1.81)

where YIELD = paddy yield in kilograms per hectare and HALABWE = weeding labor input in person-days per hectare.

The *average* opportunity cost of labor in the new rice fields (established by alternative use in upland crops and traditional rice) has already been defined by the gross margins per labor day in these crops. The estimated production functions are used to compute the *marginal* labor productivity for the various crops. It turns out that marginal returns to labor in upland crops (millet and groundnuts) were higher than in the new rice fields in the wet season of 1985/86 (Table 20). The related parameters in the production functions for the upland crops are largely robust and significant. Marginal labor productivity is lower than average productivity. Yet for the major field crops (groundnuts and upland cereals), it is still D4.60-7.50, or US\$0.91-1.48 per day.

A diagnosed low overall marginal labor productivity in the fully water-controlled rice fields (Table 20)—despite high average labor productivity over the season—does not come as a surprise. Participating farmers are under considerable pressure to adhere to a strict schedule defined by the project's management. This stresses maximum yields rather than equating marginal returns with marginal (opportunity) costs of labor. Farmers not maintaining the set schedule, and therefore achieving "inadequate" yield levels, run the risk of being expelled from the project. Farmers with a very profitable dry-season crop in the fully water-controlled area are unlikely to take that risk. Also, the relatively safer pump-irrigated crop compares favorably with the upland crops in a drought year. From a farmer's perspective, however, and in economic terms, it would have been better to spend more time on the upland crops in 1985/86, given their higher marginal returns to labor. This coincides with a reported reluctance of some farmers to follow the schedules set by the project.

Implications for Irrigation Schemes

An attempt to maximize yields in irrigation schemes without due consideration of labor's opportunity cost is suboptimal both for farmers and for the economy. Irrigation schemes in this volatile environment are destabilized by the fluctuating labor supply as a

Table 20—Average and marginal labor productivity in major crops, wet season 1985/86

Crop	Average Labor Productivity in Gross Margin per Labor Day ^a	Marginal Labor Productivity Derived from Production Functions ^b
	(dalasi/person-day) ^c	
Upland cereals (millet, sorghum, and maize)	8.88	7.50
Groundnuts	8.70	4.61
Swamp rice	5.70	3.20 ^d
Partly water-controlled rice in project ^e	7.40	3.20 ^d
Fully water-controlled rice in project ^f	14.70	1.42 ^g

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

^b The marginal labor productivity evaluated at respective mean values of labor input and average sales prices of output; for parameters, see Table 19.

^c One U.S. dollar equals 5.06 dalasi.

^d Traditional swamp rice and partly water-controlled rice in the project are dealt with in one model (Table 19).

^e These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^f These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^g The parameter on which this value is based is statistically insignificant (see footnote b on Table 19).

consequence of changing returns to labor in competing crops from year to year, which is a function of rainfall quantity and distribution. A flexible response to this situation is required—one that cautiously permits yield fluctuations due to labor reallocation—not an attempt to either enforce constantly high labor input or maintain it by an excessive subsidy to irrigation. Neither is economically justifiable.

In addition, a flexible (economic) approach to yields, which permits the irrigation schemes to fluctuate between lower yields in years of good rainfall (when labor is pulled into upland crops) and higher yields in years of low rainfall, would introduce a buffer function for local- and household-level food security. In the 1984 drought year, the Jahally-Pacharr project in fact functioned that way. Making use of this food security potential of small- and medium-sized irrigation schemes calls for a wide distribution of irrigated land across the communities in order to permit a large number of compounds to resort to irrigated rice with rather stable and high yields, even though achieved at low marginal labor productivity in drought years.

Effects on Labor Allocation and Competition with Other Crops

Given the above patterns of average and marginal returns to labor in rice under new technology versus other crops, what are the implications for and effects on labor allocation? To address this question, a labor input model is specified, as discussed in the conceptual framework (Chapter 2, equation [3]).

Given various demographic characteristics, labor inputs to crops and to nonagricultural work are hypothesized to be determined by relative net returns to labor in the various alternative activities. Only some of these basic relationships can be adequately captured in this cross-sectional analysis. Actual crop prices and farmers' price expectations are excluded because of the cross-sectional nature of the data. The main focus of the labor input analysis is to quantify the effect of access to project rice land on labor inputs to other crops. Household demographics are assumed to play a role here, as some ethnic and gender specificity of labor allocation by crop occurs. In addition, the project's labor-saving capital equipment may affect the degree of substitution between the new rice crop and other crops grown before. The crop-specific and aggregate labor input functions have the following formula:

$$LAB_{ji} = f(DEM_{ji}, LOC_i, CAP_i, RLAN_i), \quad (12)$$

where

LAB_{ji} = total labor input in person-days (paid and unpaid labor) for crop j by farm i ,

DEM_{ji} = a set of demographic variables (household size, children, women's share),

LOC_i = distance from project in terms of location of village in upland or lowland,

CAP_i = value of agricultural machine and implement capital stock per adult-equivalent person, and

$RLAN_i$ = size of area in the rice project per adult equivalent (in fully water-controlled equivalent area).

The results are presented in Table 21. The model further supports the impression from earlier tabulations that with increased availability of rice land in the project, total

Table 21—Reallocation of labor between crops: regression results

Explanatory Variable	Family Labor in All Crops		Family Labor in Upland Cereals		Family Labor in Groundnuts		Family Labor in Swamp Rice	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
Size of compound in adult equivalents	46.507	17.13	8.281	8.17	15.129	10.37	18.342	9.48
Number of children under 10 per adult equivalent	-331.021	-3.51	-58.359	-1.62	-117.043	-2.12	-72.728	-1.00
Ratio of women per adult equivalent	60.012	0.50	-47.900	-0.95	-71.842	-0.94	184.418	2.17
Location of village (1 = lowlands, 0 = uplands)	-27.989	-0.76	-68.134	-4.93	-141.641	-7.09	138.591	2.60
Machine and implement capital per adult equivalent (dalasi)	0.6672	0.72	0.2039	0.56	-0.3096	-0.62	0.4041	0.61
Amount of land in project per adult equivalent (hectares) ^a	-942.980	-1.71	-684.048	-3.18	-1,045.305	-3.04	-855.950	-2.20
Constant	200.949	3.00	157.716	6.04	227.238	5.88	-150.904	-2.28
R ²	0.614		0.420		0.556		0.508	
F-value	55.900		24.780		38.540		18.730	
Degrees of freedom	202		184		174		97	

Note: Dependent variables—family labor input in person-days by respective crop at compound level, except in the case of large Wolof and Mandinka compounds, where subcompound units are used.

^a Land expressed in "fully water-controlled equivalent" on yield basis.

labor input in agriculture is decreased rather than increased. The estimated parameter (Table 21, column 1) of -942.98 suggests that if an average compound obtains an average portion of project land (0.43 hectare), total labor inputs to agriculture are reduced by 28 days per compound, or 7.5 percent of total wet-season labor. Note that the parameter is not of high statistical significance. From the above tabulations, it was evident that it was more male than female labor input that was reduced overall (see Table 14).

More significant than this labor-input-reducing effect, which could include a "leisure effect" arising out of the income effect of the more profitable new rice fields, are the labor substitution effects to the various crops. Evaluated at the respective sample means, given access to an average piece of project land, total labor to swamp rice is reduced by 21 percent; to upland cereals, by 19 percent; and to groundnuts, by 22 percent. Clearly, the competition between labor for the new rice and labor for the upland crops and traditional rice is strong.

The opportunity cost of labor in the project has profound implications for the net benefits of technological change and its related investment. The reduction in upland cereals and groundnuts due to reduced labor allocation to these crops is crucial. The output volume of the principal nonproject crops was reduced by 19.4 percent for an average compound (Table 22). The gross income forgone due to reduced crop production outside the project amounts to D636 per compound or compound subunit in the large Wolof or Mandinka compounds.

In terms of each ton of incrementally produced paddy, this output forgone in other crops is equivalent to 161 kilograms of upland cereals, 112 kilograms of swamp rice, and 204 kilograms of groundnuts. For every incremental D100 earned in the new rice production in the wet season, D64 are lost from other crop production.

To sum up insights from this chapter, staple food supply *is* increased to the households, but at considerable cost. These costs consist of investment costs and direct operating costs in the project, and of output forgone in the other crops from which labor was withdrawn. This last cost component is frequently overlooked. The challenge for program and project design and management is to select and promote technologies at the microlevel that will enhance labor productivity. A simple focus on a high and

Table 22—Opportunity cost of project rice and production forgone from other crops due to project

Forgone Income/Production	Change per Compound ^a			Total Weighted Average
	Upland Cereals	Swamp Rice	Ground-nuts	
Gross income forgone (at average net returns per person-day, in dalasi) ^b	246	194	383	636
Crop production forgone Kilograms/compound ^c	289	201	368	...
Percent of 1985 production of each crop	19.3	38.0	17.5	19.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Average compound at sample means.

^b Computed on the basis of the gross margin computation (Table 16) and the labor input functions (Table 21).

^c Computed on the basis of the production functions (marginal labor productivities: parameters of HALAB, HALABSO) and the labor input functions (Tables 19 and 21).

stable output per unit of land can easily be misleading in this West African environment. A flexible approach to yields in such irrigation perimeters is required, guided more by overall economic considerations and less by ease of project management. This would make optimal use of scarce farm labor but would not respond with excessive subsidies or enforcement of power when labor follows economic incentives and turns away from irrigated rice in years of good rainfall that enhance returns to labor in the uplands.

EFFECTS ON MARKETED SURPLUS, STORAGE, AND INCOME

For a complete assessment of the effects of new agricultural technology on different population groups, an analysis of the demand-side effects of the increased output is as important as one for the supply-side effects. This chapter, therefore, evaluates the effects of technological change and commercialization on marketed surplus and income, while the following chapter considers the consumption of food and nonfood resources.

Marketed Surplus Effects

Cereals produced by the household are used for a variety of purposes. On the disappearance side of the balance, sales for cash are only one among many transactions, some of which constitute in-kind payments. Among these in-kind transactions are loan repayments, payment for hired labor and the renting of tools, and various types of gifts and donations. A broadened view of "marketed surplus" is required in this social environment, where gifts and donations form a large part of transactions related to a complex system of social security. Gifts may take the form of goods traded against services and may also be "true" charitable donations, bearing in mind that there is a strong obligation in this society for the receiver to repay "gifts" whenever the giver falls into a time of need (Mauss 1954).

The various uses of a harvest differ a great deal between crops and types of technologies of crop production. In the case of rice, the highest share (about 20 percent) of cash sales is observed for the swamp rice (Table 23), while only 7-12 percent of project pump-irrigated rice was sold. Thus, an inverse relationship between levels of output per unit of land and labor and percent of marketed surplus of rice is observed here. This has little to do with technology as such, deriving instead from the institutional arrangements under which each crop is produced. As discussed above, rice in the project is largely a communal crop, of which little is sold. Swamp rice, on the other hand, is a women's crop grown partly for food and partly for cash income. Similarly, very little is sold of the upland cereals (millets, maize), which are also largely grown as communal crops.

The importance of the institutional arrangements is particularly significant for the rice crops: 80 percent of swamp rice cultivated as *maruo* was actually consumed in the *sinkiro*, compared with only 58 percent of the *kamangyango* swamp rice. Similarly, we find that from the partly water-controlled rice in the project, 45 percent was retained for consumption when grown as *maruo*, but only 19 percent when grown as a *kamangyango* crop in 1984/85.

Rice cultivation in the project involves loan repayments for inputs and water charges. In 1984 these amounted to 30.1 percent of total output, but they dropped to 18.3 percent in 1985 in the fully water-controlled rice. The drop was due to upwardly adjusted output prices applied to the per-unit-of-land repayment duties. This portion of "marketed surplus" required for loan repayment is a quota and not a choice variable on the part of the farmers. Nevertheless, from a sectoral perspective it still indicates an increased commercialization of agriculture. After the disposal components of loan

Table 23—Uses of harvest, by crop and rice technology, 1984 and 1985 wet seasons

Use	Rice									
	Fully Water Controlled in Project ^a		Partly Water Controlled in Project ^b		Pump Irrigated in Old Schemes ^c		Swamp		Early Millet, Sorghum	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
	(percent of total production of each crop)									
Loan repayments	30.1	18.3	34.2	27.2	5.7	4.4	0.4	0.8	0.2	0.2
Hired labor and rents ^d	1.4	0.7	1.6	2.7	3.1	2.5	2.6	1.5	0.4	0.3
Gifts, donations	6.5	9.4	5.8	10.7	9.3	11.5	10.7	15.4	10.4	12.7
Sale ^e	7.3	12.2	15.5	6.9	8.2	2.1	19.1	20.7	2.9	0.9
Consumption ^f	54.7	60.2	42.9	52.5	73.7	79.5	67.2	61.6	86.3	85.9
									82.8	85.5
									22.5	29.0
									2.5	1.7
									0.4	1.2
									3.5	2.4
									71.1	65.7
									22.5	29.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

^d For implement rentals (in-kind repayments).

^e Including harvest given as loans for later payment (0.1-0.4 percent per crop) and exchanged in kind (barter, 0.0-0.2 percent per crop).

^f Including retained seed (1.3-5.4 percent of cereals, 10.9 percent of groundnuts) and storage losses, which are negligible on average.

repayments and some project cost recovery (the "water charges") are accounted for, the share of project rice marketed is smaller than that of swamp rice.

Nevertheless, the proportion of all rice marketed is generally higher than that of coarse grains (Table 23). Nearly all of the coarse grain produce stays in the compound, apart from donations, of which the traditional charity donation called *zakat* (a decile of the harvest) forms the largest share. Fluctuations in domestic household cereal supply and in demand (stemming from seasonal and interyear fluctuations in coarse grain production) are largely leveled out by transactions in rice. Thus it is the rice market in rural areas that equates effective demand with the general supply of cereals. In the 1984/85 year of drought and trade-determined cereal shortfalls, the marketed surplus of millet was slightly higher than in 1985/86. Yet, even in upland villages that concentrate on millet production, sales did not exceed 7 percent of total output.

In general, women farmers sell a higher share of rice produced under their control than men in the same rice technology (Table 24). Women use rice as a means to raise cash for the purchase of, for example, cooking ingredients, which are important female expenditure items. Rice sales from stocks are frequently carried out in small quantities "by the cup."²⁵ In the wet (hungry) season when most compound stocks are low, these sales are important both for the sellers (who raise cash for the purchase of ingredients) and for the purchasers. The latter are particularly short of cash during the hungry season, and they bridge this period with short-term purchases tailored to the specific circumstances of the household's ability to purchase and the timing of the first September grain harvests (roasted fresh maize cobs, fire-dried early millet).

Most by-the-cup selling is done by women. On average, women in the sample sold 2.6 kilograms of rice per week in this invisible market in the wet season. These sales correspond to 9 kilograms of paddy per *sinkiro* per week in the 55 percent of *sinkiros*

Table 24—Shares of rice harvest retained for consumption and sold, by technology and sex of farmers, 1984 and 1985

Use	Fully Water-Controlled Rice in Project ^a			Partly Water-Controlled Rice in Project ^b		Pump-Irrigated Rice in Old Schemes ^c			Swamp Rice	
	1984	1985		1984	1985	1984	1985		1984	1985
	Wet Season	Dry Season	Wet Season	Wet Season	Wet Season	Wet Season	Dry Season	Wet Season	Wet Season	Wet Season
	(percent)									
Retained for consumption										
Men	54	58	59	72	61	81	67	71	62	68
Women	51	55	60	32	51	61	75	82	64	61
Sold										
Men	7	7	11	...	7	3	10	5	16	15
Women	7	9	19	18	7	12	5	0	18	21

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Other uses of the harvest are not included; therefore, figures do not add up to 100 (see Table 23).

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

²⁵ Standard-sized tins are used for measurement. The most frequently used tin holds about 250 grams of white dehusked rice.

reporting such sales. Most of these *sinkiros* (80 percent) are in lowland villages and these sales stem largely from the dry-season crop cultivated in the fully water-controlled part of the Jahally-Pacharr project. The irrigated dry-season crop serves to even out the most severe seasonal scarcities in cereal availability. The by-the-cup sales between July and September add up to about 8 percent of the dry-season paddy harvest.

The effects of the new rice technology and the heterogeneity of cereal sales by type of farm household become more apparent if the sample is divided by lowland and upland villages and by degree of access to new project rice fields. Generally, the more the involvement in the project, the more sales of rice increase as a proportion of production (Table 25). Among compounds with a high degree of involvement in the project, the share of sales from women's swamp rice increases even more than the

Table 25—Shares of marketed surplus and own consumption of crops, by access to project rice fields, wet season 1985

Crop	Access to Rice Fields in Lowland Villages				Access to Rice Fields in Upland Villages			
	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
(percent of production of each crop)								
Rice								
Fully water controlled in project ^a								
Sales	8.8	5.1	10.8	17.5	4.1	4.3	4.5	0.0
Loan repayment	25.3	17.8	17.0	15.3	17.8	18.5	25.4	25.6
Own consumption	48.4	59.5	58.5	53.8	70.6	64.3	58.5	66.7
Partly water controlled in project ^b								
Sales	6.2	7.5	5.0	8.5	3.5	4.6	c	c
Loan repayment	17.0	22.2	28.1	31.3	26.6	25.6	c	c
Own consumption	62.7	58.2	47.5	40.7	58.4	57.0	c	c
Swamp								
Sales	15.2	18.5	24.0	29.2	8.2	0.0	c	c
Own consumption	57.9	54.5	51.0	51.8	78.7	79.5	c	c
Early millet								
Sales	1.4	0.0	0.0	0.0	1.3	7.0	4.3	c
Own consumption	80.5	88.6	84.5	76.8	84.9	82.5	71.0	c
Late millet								
Sales	c	0.0	0.0	c	7.5	c	c	c
Own consumption	c	88.0	87.0	c	69.4	c	c	c
Sorghum								
Sales	0.0	0.0	0.0	c	0.0	0.0	0.0	c
Own consumption	79.0	90.0	86.5	c	86.9	87.8	76.4	c
Maize								
Sales	8.8	3.5	0.0	0.0	3.3	1.8	0.9	0.0
Own consumption	48.4	70.5	67.7	67.1	86.2	78.3	76.7	82.9
Groundnuts								
Sales	65.0	65.3	51.6	55.1	68.7	63.8	54.8	51.5
Own consumption ^d	21.5	27.8	39.9	35.1	25.8	30.7	34.9	42.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: The quartiles are defined in terms of fully water-controlled area per adult-equivalent person in the *sinkiro* and are formed equally for the whole sample. Thus, for instance, the second quartiles in both upland and lowland villages are formed of *sinkiros* of the same quantity of land per adult equivalent on average.

^a These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

^b These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

^c No observation.

^d Own consumption includes storage of seed intended for use in the next season, which is a sizable share of these groundnuts.

sales from the project rice. These tendencies come out clearly among the lowland villages, which were traditional rice tillers before the project.

Groundnuts are both a cash and a subsistence food crop. In the lowland villages, and in households with considerable access to new rice fields, 35-40 percent of groundnut production is retained. This traditional cash crop—reduced in area and output due to labor reallocation to rice—is more of a subsistence food crop in such households, while rice has become more of a cash crop. The variable pattern of crop use within the sample, given different family and farm characteristics, underlines the limitations of the simplifying terms “subsistence food crop” and “cash crop.” These tendencies are similar in upland villages, although very little of the rice is sold in them (Table 25).

Increased market integration of agriculture is inseparable from rural development, which exploits the benefits of specialization in an expanding agricultural sector and rural economy. The above analysis highlights the complex patterns of cereal markets at the local and compound levels. Economic factors, environmental conditions, and institutional forces all influence the marketed surplus ratio of cereals. Increased output achieved through technological change in one crop does not lead to a straightforward expansion of marketed surplus. Substitution effects in production and increased consumption—desired from a nutritional perspective by many families—reduce the expected marketed surplus effects of output growth in the new rice crops. A model is used below to further evaluate the roles played by factors that shape the gross marketed surplus of cereals. The model analysis focuses on the effects of increased cereal production for sales of grain and on its short-term price elasticity (see also the conceptual framework in Chapter 2, equation [5]).

The dependent variable in the model is the quantity sold of all cereals (CERSOLD). The cereal quantities are expressed in milled equivalents out of the sum of millet, sorghum, maize, and rice. The model is specified following the hypotheses below.

It is hypothesized that an increased supply of cereals from own production (CERPROD) increases the marketed surplus. While this is certainly the case once household demand is fulfilled (accounted for by size of compound, SIZE), this demand itself can be assumed to be income-elastic. This is accounted for by the per capita income variable in the model (INCOME) approximated by the total expenditure value (cash and in kind) per adult-equivalent person.

From an increased price, an increase in marketed surplus is expected. Because of the dominance of rice in equating supply and demand on the cereals market, and the close correlation with other cereal prices, the rice price (PRICE) is used as the only price variable in the model. Price variability in the cross-sectional sample covering the 1985 season is substantial. This variability stems from local differences in linkages to market outlets and intraseasonal differences that are not independent of demand from across the border (to Senegal) as well as the related exchange rate differences that impinge on the dalasi price. To avoid disturbances in the price variable due to household-specific differences in sales timing (for instance, the poor may be selling earlier in the season at a lower price), village mean prices are used in the model. The logarithm of the price is used, assuming that the price elasticity of marketed surplus is diminishing for larger price changes.

The scope for price policy to stimulate marketed surplus at current levels of infrastructure is of interest for policy analysis purposes. Infrastructure is therefore controlled for in the model with the variable depicting distance to the main markets from each village (DISTANCE). This distance variable is included because time and transport costs to compounds that sell in bulk may not be fully captured by the village-level prices. A

potential endogeneity problem arises where local prices are partly a function of infrastructure, yet the other factors leading to village-specific price variability are also important. The potential endogeneity of prices is certainly an issue that calls for further research in these complex market environments of West Africa.

Given the dominance of rice in the grain market, an increase in the share of rice production in total cereal production (RICESH) is expected to result in an increase in the marketed surplus of all cereals. The model is, therefore, composed of

$$\text{CERSOLD}_i = f(\text{CERPROD}_i, \text{RICESH}_i, \ln\text{PRICE}_i, \text{DISTANCE}_i, \text{INCOME}_i, \text{INCOMESQ}_i, \text{SIZE}_i, \text{SIZESQ}_i). \quad (13)$$

(For details of variable definitions, see Table 26.)

The estimation results are given in Table 26. They suggest a significant positive elasticity of marketed surplus for supply and for price. Evaluated at sample means, a 10 percent increase in cereal production increases sales by 8.4 percent. A 1 percent increase in the (rice) price would increase sales by 2.9 percent, which appears to be a rather high price elasticity. Given the cross-sectional nature of the analysis, a cautious interpretation of this price elasticity is suggested. One certainly would like to assess

Table 26—Marketed surplus model for cereals: regression results

Explanatory Variable ^a	Parameter	t-Value	Mean of Variable
CERPROD	0.0701	5.89	2,401.63
RICESH	344.7470	5.50	0.57
lnPRICE	621.1690	1.91	-0.07
DISTANCE	-25.4168	-2.80	3.31
INCOME	0.0273	0.32	1,344.55
INCOMESQ	-1.8905E-6	-0.10	2,122,666.40
SIZE	0.3315	0.05	9.37
SIZESQ	-0.0876	-0.44	123.41
Constant	-46.208	-0.38	...
R ²	0.430		
F-value	18.55		
Degrees of freedom	200		

Notes: Dependent variable—cereals sold (kilograms of all cereals in milled equivalent per compound). The mean value of the dependent variable, CERSOLD, is 201.1 kilograms. The unit of observation is the compound or, in the case of some large compounds, the subunit (*sinkiro*—a cooking and consumption group).

^a Definitions of variables:

- CERPROD = cereals produced in wet season 1985 per compound (kilograms of all cereals in milled equivalent);
- RICESH = share of rice in total cereal production, wet season 1985;
- lnPRICE = rice price in dalasi/kilogram (logarithm of village mean price);
- DISTANCE = distance to main market from each village;
- INCOME = total expenditure (as income proxy) per adult-equivalent person for 1985/86 (in dalasi);
- INCOMESQ = income squared;
- SIZE = size of compound in adult-equivalent persons; and
- SIZESQ = size squared.

the marketed surplus-price relationships more closely with a dynamic model, which the data, however, do not permit. Marketed surplus shrinks with increased distance from the market place by 13 percent for every kilometer, other things held constant. The critical role of market infrastructure for market integration is highlighted by this estimation result. An increased share of rice production in total cereal production expands marketed surplus beyond the total cereal supply of the compounds. Compounds with a higher share of rice in their total cereal supply become more market-integrated as sellers (and buyers) of cereals: a 10 percent increase in the rice share leads to a 17 percent increase in marketed surplus. Thus the new rice project enhances market integration as the supply share of the most marketable cereal expands and total supply increases. Neither the income-related nor compound size-related variables show up significantly in the model.

Effects on Storage and Storage Control

Cereal storage in the compounds involves different institutional rules. The various subdivisions of the compound may or may not maintain different storage places in which their grain stock is kept under their control. The storage place of each stock is institutionally defined by the mode of production under which it was cultivated (communal or individual). The right to extract produce from these various stocks lies with the individuals or subgroups in charge of the specific storage space.

Most storage locations (47 percent) are found under the control of the compound head. Personal storage by other individuals is also widespread (28 percent of stores). Eight percent of the stores were defined as *sinkiro* (cooking unit) stores, 8 percent as *dabada* (working unit) stores, and 9 percent as other stores. Individually controlled stores usually hold only small quantities for sale to cover personal expenses. About two-thirds of all cereals stored are under the control of the compound heads. Despite remarkable fluctuations in volume stored by season, this share remains fairly constant (63 percent in the wet season and 65 percent in the after-harvest dry season when total storage is nearly four times the wet-season quantity). Women were in charge of only 15 percent of cereal stocks in the dry season (storage was assessed in February 1986), but they held about one-third of the stored rice.

The crop composition of cereal storage changes substantially between seasons. Rice made up about 90 percent of stocks held by the sample households during the wet season and 41 percent in the dry season. The remaining stocks were made up of coarse grains.

The pronounced seasonality of Gambian agriculture and food availability shows up clearly in per capita storage levels. During the hungry season an average of 16 kilograms was held in store, while in the dry season the average was 64 kilograms. The dry-season crop from the scheme obviously smooths out the seasonal differences. The overall figure for the wet season is, therefore, not representative for the country or comparable environments in the region.

This is more the case when considering the group with no or very little access to the rice project. The quartile of compounds with least access held only 4 kilograms of cereals per capita in the hungry season, compared with 29 kilograms in the top quartile. On the other hand, in the dry season 100 kilograms per capita were held by the bottom quartile versus 61 kilograms by the top. Compounds with little dry-season rice production attempt to bridge the hungry season with higher opening stocks of coarse grains from wet-season production.

Storage levels vary little by income in this setting. At the low and high storage points, the poor have about as much in stock as do the upper income quartiles. Table 27 shows this for the 75 compounds that have little or no access to the Jahally-Pacharr project. These numbers are, therefore, not much affected by the dry-season irrigated rice production. Equally low storage levels of 5-7 kilograms per adult-equivalent person in the wet season in the compounds across all income groups do not mean, however, that consumption levels are similarly uniform. This is discussed in Chapter 6.

It should be noted that averages cover variability in the storage figures. Many of the compounds with little access to dry-season rice fields have totally depleted their stocks by the middle of the wet season and survive on the basis of almost daily by-the-cup purchases of rice. Even brief disruptions in the ability to acquire food (rice) in that period of the year may result in acute food consumption shortfalls. The increased storage levels due to rice from the project in this critical period of the year certainly improve household-level food security. It is not only the average annual increase of output due to new production technology that matters in this setting, but also the seasonal timing and reliability of it. Respective aspects of these considerations are further evaluated in the following analysis on income effects.

Income Effects

The analysis of agricultural production effects of the new rice technology showed an increase in labor productivity. This is expected to translate into increased per capita income and consumption. The analysis in this section evaluates (1) the pattern and seasonal change in income sources and the role of increased rice income in this context, and (2) the effects of the new technology on distribution of income.

The analysis is based on a complete income accounting carried out for the two periods covered by the survey. Season 1 covers March-August 1985, and Season 2 covers September 1985-February 1986. Thus, Season 1 includes the dry-season crop income and Season 2, the wet-season crop. In both seasons, livestock income and income from off-farm work, craft work, and trading as well as income transfers (remittances) are accounted for. For this analysis the income data were collected at the individual level in the compounds and then aggregated at the compound or compound subunit level where applicable. Table 28 gives a breakdown of the income accounts by upland and lowland villages.

Table 27—Seasonal cereal storage in compounds outside the project, by income group, 1985/86

Season	Income Groups ^a			
	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
	(kilograms of stored cereals/adult-equivalent person)			
Wet ^b	4.6	4.6	5.0	7.0
Dry ^c	80.8	58.7	95.1	102.2

Source: Computed from 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Total expenditure per year per adult-equivalent person is used as an income proxy.

^b In August/September 1985.

^c After harvest (March 1986).

Table 28—Income in upland and lowland project villages and nonproject villages, by source, 1985/86

Income Source	Income per Adult Equivalent			Total Average
	Lowland Project Villages	Upland Project Villages	Villages Outside Project	
	(dalasi)			
Season 1 (March-August 1985)				
Rice	123	46	40	87
Animals	-5	-4	-7	-5
Vegetables	3	1	10	3
Total own agriculture*	120	42	43	85
Total off-farm	113	61	104	95
Total income (Season 1)	233	103	146	180
Season 2 (September 1985-February 1986)				
Rice	237	60	64	157
Millet, sorghum, maize	62	248	86	127
Groundnuts, cotton	95	300	151	171
Animals	-8	11	-3	-1
Vegetables	9	13	29	13
Total own agriculture*	389	625	322	460
Total off-farm	71	58	65	66
Total income (Season 2)	459	683	387	526
Total annual income	692	786	533	706

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

* Cost of tools is deducted here.

Average per capita income was US\$116 per year (at a parallel exchange rate). The average of the highest income quartile was only 3.7 times the average of the lowest (Table 29). However, the notion of homogeneous poor peasants would be grossly misleading. Although most of the income earned is from own agricultural production (77.5 percent), income from other sources is not negligible. Average nonagricultural income stands at 22.8 percent, but it is 25.8 percent in the top quartile versus 20.4 percent in the bottom. In Season 1 (March-August), nonagricultural income is more important than agricultural earnings, particularly among the poorest. Income from animal production was on average negligible at the study site in 1985/86. This may be due to low prices in the drought year 1984/85, animal losses, and low sales volume in 1985/86.

In the lowest income quartile, the seasonality of the income flow is most pronounced: 80 percent of income is earned in the second season, while it is 72 and 75 percent in the two upper quartiles. Season 1 and Season 2 income is significantly correlated. In other words, the poor are poor in both seasons. Consequently, annual income correlates significantly with hungry-season income with a correlation coefficient of 0.48.

Rice production (including rice for own consumption) is a major income source in the sample compounds. An average of 34 percent of total annual income derives from rice, yet the importance of rice for income varies widely. In compounds from villages outside the project, rice production generates only 20 percent of total income (Table 28). This situation may be comparable to the preproject situation, since the two study villages outside the project are lowland communities with swamp rice and some old-scheme rice production. In the lowland villages of the project, rice (from all sources) now contributes 52 percent of income, while it is 13 percent in the upland villages

Table 29—Main income sources, by level of per capita income, 1985/86

Income Source	Per Capita Income Groups				Total Average
	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	
	(percent of annual income)				
Season 1 (March-August 1985)					
Own agriculture	7.3	12.5	15.6	10.7	12.1
Off-farm work and transfers	12.8	12.7	12.5	14.6	13.5
Total	20.2	25.2	28.2	25.3	25.6
Season 2 (September 1985-February 1986)					
Own agriculture	72.2	66.4	64.0	63.4	65.4
Off-farm work and transfers	7.6	8.3	7.8	11.2	9.3
Total	79.8	74.8	71.8	74.7	74.8
Total annual	100.0	100.0	100.0	100.0	100.0
Total annual income per adult equivalent (dalasi)	327	568	767	1,147	703
Total annual income per adult equivalent (US\$)*	65	112	152	227	139
Total annual income per person (US\$)*	64	93	127	189	116
(Number of observations)	(55)	(56)	(56)	(57)	(224)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

* Converted at parallel exchange rate (US\$1.00 = 5.06 dalasi).

(new tillers). In the top quartile of compounds with the most access to new rice fields, rice provides 67 percent of annual income. This is also the group with the least seasonal fluctuation of income due to the fully water-controlled technology, which ensures an income source in the hungry season.

Rice production has relatively greater importance for the poorest farmers (43 percent of income) than it has for the top income quartile (26 percent). The new rice technology has contributed—at least in the short run—to a more equal distribution of income in the area. The households that would benefit most from further improvement in labor and land productivity of rice are those currently earning a high share of their income in rice, and this is relatively more the case for the poorer households. This also means that any deterioration in yields in the project would most adversely affect poorer households.

Determinants of Income Differences

The causes of income differences in rural West Africa do not lend themselves to easy conceptualization. Socioanthropological determinants, such as status, lineage, and ethnicity, which determine access to and control over resources, play a major role and interact with more general economic factors, such as acquired human capital and the capital stock for agricultural production (tools, livestock) (Hill 1970, Meillassoux 1981). An attempt is made below to identify the factors that determine income differences in this area through an income-earning model and to assess the incremental role of access to new rice technology in this context (see also conceptual framework, Chapter 2, equation [6]).

The following hypotheses underlie the multivariate analysis. The main factor of production in all income-earning activities in the area is labor. The size and demographic composition of a compound (size of work force, share of women and children, age of

compound head) is crucial for its income earning. Endowment with human capital is difficult to assess in this environment, where almost invariably a few years of Koranic school training is obtained by the heads of the households. Yet, acquired skills in craft work are of importance and are included in the model. Where production is concerned, agricultural income—the main income source—is hypothesized to be determined (beyond labor) by agricultural capital (that is, labor-saving equipment and the size of livestock herds). Access to project land can be interpreted as a capital asset, too. It is included to test for its effects besides the other factors mentioned. The model also tests whether a higher share of communal agriculture (*maruo*) reduces efficiency—a compound labor force might be more concerned with its private fields—and thereby the per capita income of compounds. Finally, the effect of ethnic differences (that is, Serahuli who are more involved in craft work and trading) was tested, and whether compounds residing longer in the area do better. The model is thus specified as follows:

$$\text{INCOME}_i = f(\text{HHDEMO}_i, \text{QUALJOB}_i, \text{AGCAPITAL}_i, \text{MARUOSH}_i, \text{FOUNDED}_i, \text{SERAHULI}_i, \text{LOCATION}_i), \quad (14)$$

where

- INCOME_i = income per capita (adult equivalent) in dalasi per year (1985/86);
 HHDEMO_i = compound size and demographics (see variables WORKPERP, CHLDAE, WOMENSH, AGECH in Table 30 notes);
 QUALJOB_i = human capital-related variable (qualification as craftsman);
 AGCAPITAL_i = agricultural capital-related variables (see AGTOOL, ANIMUNIT, NEWRICE in Table 30 notes);
 MARUOSH_i = share of land under communal crops in total crop land;
 FOUNDED_i = if compound was founded long ago (>10 years) = 1, else = 0;
 SERAHULI_i = if compound is Serahuli = 1, else = 0; and
 LOCATION_i = if compound is in lowland village = 1, else = 0.

The estimation results of this income-earnings analysis are presented in Table 30. From the model results, four points should be highlighted:

1. On the average, an additional plot of new rice land allotted to a compound significantly increases per capita income by D92 per adult-equivalent person per year. This is equivalent to 13 percent at the sample mean.²⁶ That this is a fairly stable and reliable income increase is noteworthy. This result for the net income effect appears to be consistent with the earlier findings of major substitution effects (labor) between crops in compounds with access to new rice land (Chapter 4).

²⁶ One plot equals 0.5 hectare divided by 9.2 adult-equivalent persons (per compound or compound subunit) multiplied by the parameter value of NEWRICE (1,688.5), which is on a per hectare basis.

Table 30—Determinants of income differences and the role of new rice technology for income

Variable ^a	Parameter	t-Value	Mean of Variable
WORKPERP	6.913	1.15	5.78
CHLDAE	-333.641	-3.77	0.57
WOMENSH	-81.822	-0.67	0.51
AGECH	-69.591	-2.37	6.12
QUALJOB	290.364	2.83	0.14
AGTOOL	232.336	3.61	0.29
MARUOSH	48.242	0.54	0.59
ANIMUNIT	44.986	3.62	1.29
NEWRICE	1,688.496	3.39	0.06
FOUNDED	57.857	1.25	0.69
SERAHULI	249.633	2.43	0.05
LOCATION	13.362	0.22	0.44
Constant	973.386	4.84	...
R ²	0.256		
F-value	5.75		
Degrees of freedom	200		

Notes: Dependent variable—annual income per adult equivalent. Mean value of dependent variable, INCOME, is 705.03 dalasi. Unit of observation is the compound or, in the case of some large compounds, the subunit (*sinkiro*—a cooking and consumption group).

^a Definitions of variables:

- WORKPERP = persons in working age present in compound;
- CHLDAE = ratio of number of children under 4 years of age over adult-equivalent persons;
- WOMENSH = share of women in WORKPERP;
- AGECH = age of compound head (age groups 4 . . . 7);
- QUALJOB = ratio of number of persons with special skills over WORKPERP (for example, craftsmen, healers);
- AGTOOL = dummy = 1, if access to multipurpose tool for weeding and other purposes;
- MARUOSH = share of communal land in total land use of compound;
- ANIMUNIT = number of animals per adult person (animals converted to cattle equivalents on value basis);
- NEWRICE = amount of land in the rice project in hectares per adult equivalent (land in fully water-controlled equivalents);
- FOUNDED = dummy = 1, if compound was founded more than 10 years ago;
- SERAHULI = dummy = 1, if ethnic group is Serahuli; and
- LOCATION = dummy = 1, if lowland village.

2. An increased share of persons with specific skills for nonagricultural income-earning significantly increases per capita income (QUALJOB).

3. Accessibility of labor-saving tools (AGTOOL) increases per capita income, all else remaining the same, by 34 percent; the livestock effect for income is significant but not very large in terms of proportion to income (D45 per cattle unit); and increased share of communal agriculture does not appear to reduce per capita income (MARUOSH).

4. Over and above the discussed determinants of income, compounds in upland villages do not have significantly different income levels from those in lowland villages, but it is found that the Serahulis are significantly richer than the rest of the sample's ethnic groups.

Effects at Intrahousehold Level

In view of the very heterogeneous economic situation within the compounds, the distributional effects of the new technology should be considered not only at the aggregate household level, but also at the intrahousehold level. Considerable attention has been focused on the issue of intrahousehold resource distribution in recent years, following a growing recognition that neither poverty nor development interventions affect all members of the household uniformly (Lele 1986, Folbre 1986, Haaga and Mason 1987). There is a practical concern that project and policy initiatives that raise overall household incomes may at the same time be the cause of shifts in patterns of intrahousehold resource allocation that result in a negative effect on certain individuals. This concern relates primarily to the differential effect of changes on women versus men, and on different age groups within the household (Due 1987).

As was described earlier, compounds are stratified internally by various age/sex/status hierarchies, and may also be divided into subunits that operate on a semiautonomous basis. The benefits and burdens of technological change and commercialization can, therefore, be spread very differently among these various groups.

For example, it has already been emphasized that the introduction of the new rice production technology led to a transformation of the status of the crop: traditionally a women's crop grown to a large extent on private farms, it became mainly a communal crop under the authority of the male compound head. Yet this transformation in the status of rice involved more complex changes in the system at the intrahousehold level than a simple switch from a woman's to a man's crop. The reassignment of rice as a communal crop has (1) led to an increase in the burden of communal agricultural work for both men and women, but relatively more for women; (2) reduced the opportunity for women to grow rice as a private cash crop; and (3) resulted in an increasing centralization of authority in the compound head, manifested primarily in his newfound control over the rice crop (von Braun and Webb 1989).

The designation of project rice as a full-fledged communal crop has meant that the labor demands of communal farming as a whole have increased substantially in absolute terms. The burden of communal labor has therefore increased for both men and women, relative to the burden of private agriculture. Yet in this shift, the women's share of work in communal agriculture has risen relatively more than the men's. At the same time, the swamp fields, which women formerly cultivated with traditional rice (largely as a mixed private and communal crop) were much reduced in favor of the new rice plots. Both of these changes have led to a reduced ability of individual farmers (especially women, but also some junior male compound members) to maximize individual profit as private farmers and to a resultant centralization of power in the hands of senior male compound members.

This is not to imply, however, that women are necessarily dispossessed of all individual farming rights or of an independent income. It was shown in Chapter 4 that women organize private production of upland cash crops, such as groundnuts and cotton. In addition to this upland income, many women are also paid by the compound head for work that they carry out in the new project rice fields. Table 31 shows that payments ranging from 0.08 to 2.58 kilograms of rice have been given to women for each day of work that they spend in the communal project fields. The variability of payments by village is dictated by the extent to which those villages were formerly involved in swamp rice production and by the amount of swamp rice land still available for cultivation to the women in the various communities. (For example, of the eight project villages, Pacharr has the largest amount of swampland still available to its women and therefore shows one of the smallest payments.)

Table 31—Intrahousehold payment to women for work in project communal rice fields, wet season 1985

Village	Rice Given to Women by Compound Head for Work in Communal Fields	Number of Observations
	(kilograms/day of work)	
Traditional rice growers		
Dasilameh	1.95	62
Pacharr	0.08	104
Sinchou Abdou	1.30	15
Sukurr	2.58	27
New rice growers		
Njoben	a	...
Sare Samba Sumali	0.24	16
Kussalang	a	...
Sare Bala	a	...
Total mean	1.23	224
(US\$/day)	(0.35)	

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

a Women from these villages work very little in *maruo* (communal) rice (fewer than 10 cases observed in all three villages).

A payment of 2 kilograms per day is equivalent to a daily wage rate of around D2. This is the same amount as a woman's net returns from cultivating a private field of cotton, which was the least productive of the women's crops, but less than the average returns gained by women from swamp rice (Table 17). The highest in-kind payments to women were recorded in Sukurr and Dasilameh (traditional rice-tilling villages), with much lower rates of payment in the Fula villages and in Njoben (a Wolof village).

Combined with these readjustments in divisions of labor by sex and crop, and the altered sources of private farm income for women, there has been an overall centralization of control over the rice crop by the compound head and an associated increase in his authority. For example, the following responsibilities related to rice were mostly in the hands of women when growing swamp rice before the introduction of the new rice technology and are now mainly the purview of the compound head: demarcating plots (between communal and private portions), controlling activities in the fields, assessing how much rice to sell or store, deciding in whose store to keep the rice, and determining the quantity of rice to be used for cooking each day. Because the new rice is a communal crop, women automatically have a reduced say in its production and disposal.

Inevitably, not all women and men have benefited from the increased male involvement in rice production. In compounds with relatively few upland fields that can be taken over by women, or in those where compound heads do not pay women for their work in the new rice fields, women have suffered an absolute increase in work and a decline in independent income. In other compounds women are faring much better than in former days. A great variety of gainer-loser patterns is apparent. To assess these patterns completely from the income side by looking at time allocation is difficult. Fungibility between male and female income and time, for instance, is difficult to capture. The following consumption and nutrition analysis sheds additional light on the welfare effects for the various compound members and addresses the intrahousehold issues from a different angle.

FOOD AND NONFOOD CONSUMPTION EFFECTS

The findings reported in the previous sections showed that technological change in rice greatly increased rice production and added substantially to household food production. Because of substitution effects, net income effects were less sizable. This chapter addresses the extent to which these increases translate into spending on food and nonfood items, availability of food from own production for consumption, and actual consumption of food (in the form of calories). Particular attention is focused on the seasonal effects on food consumption because the study site is well known for its wet-season deficiencies in food availability, which coincide with the highest energy expenditures during this period of heaviest agricultural workload. The dry-season, pump-irrigated rice was found to reduce fluctuations in seasonal cereal availability.

Spending on Food and Nonfood

What do rural households in The Gambia spend their income on, especially their incremental income, and what role does increased income deriving from new rice technology and commercialization play in this context?

The following expenditure information is aggregated on the basis of *sinkiro*-level food consumption (the common pots) and expenditure information from person-by-person recall surveys in each season. In the case of the individual data, about 800 adults were interviewed concerning the previous week's expenditure on food snacks by themselves and their children and on both short-term and long-term nonfood expenditures.

Fifty-six percent of all expenditures (including the value of own-produced food) is devoted to communal food consumption in the *sinkiro*, 10 percent is spent on snack foods, 17 percent on frequently purchased nonfood items (such as soap and tobacco), and 17 percent on (semi-) durables, such as housing, clothes, and household goods. There is considerable stability in the budget shares for these aggregates over the two seasons. Savings, borrowings, and the seasonal depletion and rebuilding of capital stocks all serve to level out the seasonality of agricultural income flows.

There are significant changes in expenditure levels on certain individual items. For example, health expenses are higher during the disease-prone wet season than during the dry season. Housing expenses are concentrated in the late dry-season months when less field work permits more time to be spent on construction work (the wet season 1985 recall period covers the prerains period of 1985). Clothes are typically purchased after money from the groundnut harvest comes in early in the dry season.

Total expenditures substantially exceed recorded total income but the two are reasonably correlated ($r = 0.64$). While part of the difference is probably due to the common underreporting of income, the particularly large difference in the wet (hungry) season of 1985 is mostly the result of household selling of assets for current expenditures in that season, which was particularly difficult after several years of low rainfall.

The share of food expenditures fluctuates more in upland villages between seasons than it does in lowland villages, because the latter have access to more pump-irrigated rice (a second crop) with its leveling effects on seasonality (Table 32). The larger fluctuation in the food budget of upland villages is paralleled by larger absolute seasonal fluctuations in their nonfood budgets.

Table 32—Budget shares of own-produced and purchased food and nonfood items in upland and lowland village sinkiros, by season, 1985/86

Item	Lowland Villages		Upland Villages	
	Wet Season	Dry Season	Wet Season	Dry Season
Common food				
Dalasi/adult-equivalent person	292	442	312	488
Percent of total expenditures	52.9	54.8	61.4	55.1
	(percent of common food)			
Rice	49.3	43.8	38.1	19.4
Millet, sorghum	1.3	12.9	13.5	34.5
Maize	0.6	0.7	3.5	2.8
Groundnuts	4.2	6.7	10.2	18.0
Sauce ingredients	10.1	10.3	6.5	8.4
Vegetables	7.9	4.8	9.4	3.2
Oil	4.8	4.0	2.9	2.2
Fish	6.0	5.7	3.2	4.3
Meat	4.9	4.5	5.0	4.4
Milk	4.0	1.1	4.2	0.5
Sugar	5.2	4.7	3.1	1.9
Other	2.0	0.9	0.4	0.5
Snack food				
Dalasi/adult-equivalent person	50	85	39	96
Percent of total expenditures	9.0	11.2	6.8	11.2
	(percent of snacks)			
Groundnuts (as snacks)	6.5	13.8	4.8	16.3
Bread	33.8	18.6	38.3	21.2
Beverages	14.4	31.5	12.7	27.9
Fruits	21.9	19.8	7.2	13.8
Sugar	19.8	13.3	32.7	20.2
Other	3.6	3.0	2.9	0.7
Frequently purchased nonfood				
Dalasi/adult-equivalent person	109	135	91	136
Percent of total expenditures	20.0	17.4	16.3	16.0
	(percent of frequently purchased nonfood)			
Washing soap	27.6	32.0	29.8	32.0
Energy	17.6	16.9	16.9	16.2
Batteries	10.0	9.3	14.1	17.3
Tobacco, cola nuts	36.9	29.6	34.1	30.9
Transport (short distance)	6.0	8.5	3.9	3.4
Semidurables				
Dalasi/adult-equivalent person	104	131	85	159
Percent of total expenditures	18.2	16.7	15.5	17.7
	(percent of semidurables)			
Housing	4.4	2.7	5.2	2.5
Household goods	19.3	18.4	17.5	15.9
Clothes	31.1	38.6	30.0	39.8
Luxuries	7.7	9.3	10.1	7.9
Health	6.6	4.9	5.9	2.8
Education	2.0	2.4	0.7	0.1
Travel (long distance)	4.1	3.9	4.2	2.7
Festivities	4.8	5.3	6.8	4.8
Bride price	4.0	2.6	3.8	5.6
Miscellaneous	9.4	5.5	7.2	9.2
Taxes	5.8	6.6	8.6	8.7
Total expenditures (dalasi/adult-equivalent person)	555	793	527	879

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: A *sinkiro* is a cooking and consumption group within a compound. Parts may not add to totals because figures represent the means of share means.

The nonagricultural rural economy benefits from increased income earned from rice production and spent on locally produced goods and services. Table 33 gives a breakdown of average expenditures for the lowest and highest expenditure quartiles. On the basis of this information, it can be calculated that an increase in total expenditure of 10 percent causes expenditures on (semi-) durables to rise by 14.5 percent and expenditures on housing and household goods to rise by 24 percent. Changes in nonfood expenditures, however, start from a very low base. Thus, despite substantial relative changes, the multiplier effects of this increased spending for nonagricultural employment may remain small for the time being. Nevertheless, the potential for nonagricultural growth stimulated through the agricultural growth at the study site is substantial. An increasing diversification of the local economy is observed in the central market village of Brikama Ba (next to Dasilameh), where tailors, goldsmiths and silver-smiths, furniture and pot makers, weavers, and car mechanics have converged in the past few years to profit by the increased rice trade.

The tendency to spend incremental income on food is high in this area. This is looked into with a simple regression model, explaining food expenditure levels. The model is formulated with the following hypotheses in mind: a *sinkiro*-size variable (HHSIZE) supposedly controls for scale effects. The variable "income earned from cultivation in new rice project over total income earned in both seasons by *sinkiro* (PROJINC)" tests for effects of new technology in rice production on spending for food beyond its income effect, which is controlled for with the total expenditure variable as an income proxy (lnTOTEX). It is expected that the propensity to spend on food decreases with rising income (lnTOTEXSQ). It should be noted that the value of own-produced food consumed by the *sinkiro* (priced at respective purchase prices) is included in the food expenditures.

$$\text{FOODEX}_i = f(\text{HHSIZE}_i, \text{lnTOTEX}_i, \text{lnTOTEXSQ}_i, \text{PROJINC}_i), \quad (15)$$

where

FOODEX_i = expenditure on food (including value of own produced) per adult-equivalent person in wet and dry seasons in *sinkiro* (i),

HHSIZE_i = number of adult-equivalent persons in *sinkiro*,

lnTOTEX_i = total expenditure (log) in both seasons in *sinkiro* per adult-equivalent person,

$\text{lnTOTEXSQ}_i = \text{lnTOTEX}_i$ squared, and

PROJINC_i = income earned from cultivation in new rice project over total income earned in both seasons by *sinkiro*.

The estimation results are presented in Table 34.

It is found that an increase in income from the project does not significantly alter spending behavior toward food beyond its income effect. The parameter value for the variable PROJINC is statistically insignificant. Larger *sinkiros* spend less per capita for any additional member. This may be so because acquisition and preparation of food in bulk in the larger *sinkiros* permits savings.

Applying the parameters to sample mean values suggests that a 10 percent increase in total expenditure leads to a 9 percent increase in food expenditure or, in other words, of an incremental D1.00, D0.60 is spent on food.

Table 33—Budget shares of own-produced and purchased food and nonfood items in sinkiros, by expenditure quartile and season, 1985/86

Item	Lowest Expenditure Quartile		Highest Expenditure Quartile	
	Wet Season	Dry Season	Wet Season	Dry Season
Common food				
Dalasi/adult-equivalent person	196	313	432	711
Percent of total expenditures	59.2	58.8	53.5	54.9
	(percent of common food)			
Rice	48.8	33.2	36.3	35.1
Millet, sorghum	7.7	26.8	9.2	15.2
Maize	1.9	1.4	1.0	1.8
Groundnuts	5.6	12.0	7.1	10.3
Sauce ingredients	8.2	8.0	9.4	9.9
Vegetables	9.2	3.9	8.0	4.8
Oil	2.3	1.7	5.0	4.4
Fish	4.5	5.2	5.5	5.7
Meat	3.6	3.4	7.3	5.8
Milk	2.6	0.9	4.9	1.1
Sugar	4.5	3.2	4.4	4.8
Other	1.2	0.4	2.0	1.3
Snack food				
Dalasi/adult-equivalent person	27	49	72	133
Percent of total expenditures	8.1	9.7	8.7	11.3
	(percent of snacks)			
Groundnuts (as snacks)	5.6	15.9	6.5	13.3
Bread	37.1	22.3	35.6	20.4
Beverages	12.2	25.9	17.6	30.2
Fruits	15.1	20.5	14.1	15.8
Sugar	24.7	13.2	23.6	17.2
Other	3.3	2.1	2.6	3.0
Frequently purchased nonfood				
Dalasi/adult-equivalent person	60	82	143	200
Percent of total expenditures	17.8	15.9	17.7	15.9
	(percent of frequently purchased nonfood)			
Washing soap	27.7	33.5	32.1	29.3
Energy	16.8	16.6	17.6	16.2
Batteries	11.6	10.3	11.8	13.9
Tobacco, cola nuts	40.0	32.7	33.6	31.3
Transport (short distance)	3.6	4.4	3.7	6.0
Semidurables				
Dalasi/adult-equivalent person	49	79	166	230
Percent of total expenditures	14.9	15.5	20.1	17.0
	(percent of semidurables)			
Housing	4.0	1.7	6.8	2.5
Household goods	16.4	18.7	20.0	17.2
Clothes	32.2	42.6	28.9	33.5
Luxuries	7.3	6.5	10.3	12.0
Health	6.5	3.8	5.9	5.0
Education	2.2	1.7	1.3	1.2
Travel (long distance)	3.0	2.8	5.0	3.4
Festivities	6.1	3.6	5.4	4.5
Bride price	2.8	1.3	4.1	5.9
Miscellaneous	8.0	7.3	7.6	7.0
Taxes	9.7	10.2	4.6	7.2
Total expenditures (dalasi/adult-equivalent person)	331	523	813	1,273

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: A *sinkiro* is a cooking and consumption group within a compound. Parts may not equal totals because figures represent the means of share means.

Table 34—Spending on food: regression model

Explanatory Variable	Parameter	t-Value
HHSIZE	-12.64	-6.11
PROJINC	-53.33	-1.19
lnTOTEX	-8,096.71	-9.83
(lnTOTEXSQ)	615.28	11.00
Constant	27,378.81	9.03
R ²	0.835	
F-value	255.9	
Degrees of freedom	202	

Notes: Dependent variable—expenditure on food in *sinkiro* during wet and dry seasons per adult-equivalent person. A *sinkiro* is a cooking and consumption group within a compound.

The high level of food expenditure elasticities confirms findings from other African surveys reported by Alderman (1986, 38): low-income rural households in two regions of Nigeria show elasticities of 0.89-1.04, and in Sudan, 0.84.

As reported in the next section, calorie consumption increases with rising income, but decreasingly so at the margin opposite to the total food expenditures. Thus it is less a quantity effect than a quality effect in foods consumed that pushes food expenditures relatively upwards. As shown in Table 33, the budget shares of expensive food items such as oils, fish, meat, milk, and snack foods increase disproportionately with higher total expenditures, and more so than the relative reduction in spending on basic foods.

Clearly, demand for food remains high across all income groups. The absolute value of per capita cereal consumption in the top expenditure quartile is 75 percent higher than in the bottom quartile. It can be safely assumed that any income-generating activity in this area will stimulate a rapid expansion in food demand. This has implications for the rapid expansion of food production in rice projects such as the Jahally-Pacharr. It should not come as a surprise that increased food production, adding to income and thus to demand for food (including staples), does not add much to marketed surplus at current consumption levels. Effects of increased income for consumption and nutrition should be expected to be significant under these circumstances.

Calorie Consumption and Sources of Food Energy

In 1978-81, FAO food balance sheets calculated the average daily per capita supply of energy in The Gambia to be 2,251 calories and of protein to be 57 grams (FAO 1985b). (The energy estimate was 4.1 percent less than that made a decade earlier.) Food balance sheets, which provide an estimate of food available for The Gambia as a whole, are based on production, trade, and stock figures, which may not be easy to calculate precisely. Moreover, they do not provide information on geographical, socioeconomic, or seasonal variations in food availability, which may be of considerable nutritional importance. Such information is obtained from household (or individual) food consumption surveys, of which there have been comparatively few in The Gambia.

In 1946, in a small but classic study, Doughty (1950) examined food consumption in five *sinkiros* in Yoro Beri Kunda, a village in our survey area. The annual average figures reported for individual compounds range between 2,365 and 1,556 calories per capita per day in this small but carefully conducted survey. Monthly figures range between 1,240 in the hungry season and 2,780 in the postharvest season.

In 1978/79, in a survey in Lower River Division (about 100 kilometers west of our survey area), Phillips, Coles, and Seaman (1982) studied two lowland villages and

found that, on average, seasonal variations in energy consumption were comparatively small. For one village, average per capita calorie intakes were 1,920 in the dry season (March), 1,848 in the wet season (July-September), and 2,147 postharvest (December). For the other village, the figures were 2,110, 2,186, and 2,262 calories, respectively. However, substantial differences were identified in calorie consumption between households. In the dry season, per capita calorie intakes ranged from 1,445 to 2,499 in the 20 main sample households. In the rainy season, the variation between households was from 1,355 to 2,811 calories (Phillips, Coles, and Seaman 1982, 104-105). The surveys of Doughty (1950) and Phillips, Coles, and Seaman (1982) were based on several consecutive records for each time period. The weighed method was used for household food consumption, with individual recall for snacks. Phillips, Coles, and Seaman found that protein intake was above recommended requirement levels throughout the year, mainly because of high groundnut consumption. Since the area of the present study is probably similar in that respect, the following analysis concentrates on calorie consumption and not on protein.

Survey Technique

The reported calorie consumption data below are based on *sinkiro*-level information collected for one week in the rainy season (August-September 1985) and one week in the dry season (February-March 1986). All locally available foods, whether produced by the household or acquired otherwise, are included. Considerable care was taken to also collect information at the individual level on consumption of snack foods, especially the energy-dense ones, such as sweet bread, roasted groundnuts, and sugar. Mothers responded for their children on snack consumption. The *sinkiro*-level information was obtained from the head cooks who were preparing food during the week in question. The recall of food prepared by type and quantity (in local volume measures) worked backwards meal-by-meal and day-by-day.

The number of persons present at meals fluctuates to some extent. Compound members may eat with other *sinkiros*, or omit a meal when shopping at the market, and so on. An effort was therefore made to establish the precise number of persons (adults and children) present at each meal, including visitors.

Certain comments may be made about the methodology. First, in this society, head cooks have little difficulty recalling food prepared, since this is their special function in the *sinkiro*'s daily activities. In more complex situations involving several cooks, several interviews were done for the recall period for the respective days of the week.

Second, the range of foodstuffs available (and particularly those used in quantities to properly affect calorie consumption) was rather small. The measurement made was of food as prepared and served in the *sinkiro*. Since communal dishes were used, individual food consumption could not be obtained. No deduction was made for leftovers, some of which may have been wasted rather than subsequently consumed. Although Phillips, Coles, and Seaman (1982) found this wastage to be very small overall, failure to take account of it will tend to result in slight overestimation of calories consumed (particularly, perhaps in the richest households).

Chronic and Seasonal Hunger

Average per capita calorie consumption in the *sinkiros* was 2,159 in the wet season and 2,269 in the dry season. To this is to be added the consumption of snack foods consumed between meals. These snacks add up to another 221 calories (9.3 percent of total calorie consumption) in the wet season and 253 calories (10 percent) in the dry season.

Table 35 presents the calorie consumption data by expenditure quartiles. This clearly shows the strong positive relationship between income—using total expenditure as a proxy—and calorie consumption. As expected, the relationship is much stronger in the food-scarce wet season than in the dry season (after harvest). Calorie consumption increases by 54 percent from the lowest to the highest quartile in the wet season, but by only 37 percent in the dry season. While in the top quartile, calorie consumption is almost stable over the seasons (+2 percent from wet to dry season), it increased by 15 percent in the bottom quartile. Thus, food consumption by the poor reflects seasonal food scarcity, while the richer *sinkiros* are able to maintain a more constant food intake at a higher level.

Of particular concern are levels and changes of food poverty, that is, deficiencies in food calories in relation to needs. A strong inverse relationship is found between income level and prevalence of calorie deficiency (Table 36). For this particular computation, a requirement level of 2,700 calories per adult-equivalent person was chosen.²⁷ The prevalence of deficiency is presented for *sinkiros* that fall below 80 percent and below 60 percent of that level. In the hungry season, 18.4 percent are found below 80 percent and 4.2 percent are below 60 percent. By far the largest share of these *sinkiros* are in the lowest income group. Of the other *sinkiro* groups, in both seasons, only a negligible share falls below the 60 percent threshold, some of which may be "reporting noise" in the data. In the study by Phillips, Coles, and Seaman (1982), 30 percent of the 20 sample *sinkiros* had intakes below 80 percent of requirements in the wet season, compared with 10 percent in the dry season (although none were below 60 percent). The relatively higher proportion of *sinkiros* with intakes below 80 percent of requirements (as calculated according to FAO/WHO recommendations) may reflect a situation common for areas without pump-irrigated rice.

A comparable breakdown is given for *sinkiros* with different levels of access to rice fields in the project (Table 37). While deficiencies appear highest in the *sinkiros* that do not participate in the project at all, the picture remains mixed for the others. In the wet season, when project participants are benefiting from the harvest of the pump-

Table 35—Calorie consumption per capita, by income quartile, wet season 1985 and dry season 1986

Income Quartile ^a	Wet Season 1985			Dry Season 1986		
	Sinkiro Food ^b	Snacks	Total	Sinkiro Food ^b	Snacks	Total
(calories/capita/day)						
Lowest	1,724	169	1,893	2,006	170	2,176
Second	2,009	213	2,222	1,981	245	2,226
Third	2,402	220	2,622	2,526	285	2,811
Highest	2,616	301	2,917	2,648	324	2,972
Total average	2,159	221	2,380	2,269	253	2,522

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Expenditure is used as a proxy for income.

^b A *sinkiro* is a cooking and consumption group within a compound.

²⁷ Any calculation of energy requirement involves an element of judgment. Consideration has been given to recent work on women's energy expenditures and the energy cost of pregnancy and lactation by the Medical Research Center (MRC) unit in The Gambia (see Lawrence et al. 1989).

Table 36—Prevalence of calorie consumption below recommended requirement levels, by income quartile and season, 1985/86

Income Quartile ^a	Below 80 Percent of Requirements		Below 60 Percent of Requirements	
	Wet Season	Dry Season	Wet Season	Dry Season
	(percent of <i>sinkiros</i>) ^b			
Lowest	49.1	21.2	15.1	3.9
Second	17.3	18.5	0.0	5.6
Third	5.6	5.7	0.0	1.9
Highest	1.9	0.2	0.0	0.0
Total average	18.4	13.7	4.2	3.3

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Expenditure is used as a proxy for income.

^b A *sinkiro* is a cooking and consumption group within a compound.

irrigated dry season crop, increased access to project land is equated with reduced prevalence of calorie consumption deficiencies except in the lowest quartile (which includes a large share of high-income upland farm units). In the dry season, however, the picture is reversed. A considerable portion of those *sinkiros* farming large areas of project land do not consume sufficient calories (17 percent in the top quartile). This must be assessed more rigorously in a multivariate analysis that controls for other factors. Thus this simple tabulation must not be interpreted in a cause-effect perspective. Nevertheless, there are participants who experience calorie-intake deficiencies despite substantial access to the project. These are poor rice farmers with few other income sources.

The most important calorie source in the area is rice. Over both seasons, an average of 55 percent of calories comes from rice, compared with 65 percent in the wet season and 46 percent in the dry season (Tables 38, 39, and 40). While annual averages of that share show little change across income groups, poorer *sinkiros* tend to consume

Table 37—Prevalence of calorie consumption below recommended requirement levels, by access to project rice fields and season, 1985/86

Access to Rice Fields ^a	Below 80 Percent of Requirements		Below 60 Percent of Requirements	
	Wet Season	Dry Season	Wet Season	Dry Season
	(percent of <i>sinkiros</i>) ^b			
No land in project	20.7	27.6	6.9	13.8
Lowest quartile	17.0	8.7	6.4	0.0
Second quartile	22.2	8.9	0.0	0.0
Third quartile	17.8	11.4	6.7	2.3
Highest quartile	15.2	17.0	2.2	4.3
Total average	18.4	13.7	4.2	3.3

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Project land in pump-irrigated equivalent per adult.

^b A *sinkiro* is a cooking and consumption group within a compound.

Table 38—Sources of calories consumed in sinkiros, by expenditure quartile, wet and dry seasons, 1985/86

Source of Calories	Per Capita Expenditure Quartile of Sinkiros ^a				Total Average
	Lowest	Second	Third	Highest	
	(percent of total calories consumed) ^b				
Rice	53.0	60.2	52.1	54.2	54.8
Millet, sorghum	22.4	13.8	16.4	13.7	16.6
Maize	2.1	1.4	2.8	1.8	2.0
Total cereals	77.5	75.4	71.3	69.7	73.4
Groundnuts	10.7	8.9	11.9	10.8	10.6
Sauce ingredients	0.8	0.8	0.8	0.9	0.8
Vegetables	0.9	0.9	0.8	0.9	0.9
Oil	1.6	2.7	4.0	4.6	3.2
Fish	2.5	2.9	2.5	3.1	2.8
Meat	1.3	1.9	2.2	2.8	2.1
Milk	1.2	1.8	1.6	1.6	1.5
Sugar	3.3	4.5	4.4	5.0	4.3
Other	0.2	0.2	0.5	0.7	0.4
(Average calories/day/adult-equivalent person)	(2,117)	(2,355)	(2,846)	(2,952)	(2,570)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a A *sinkiro* is a cooking and consumption group within a compound.

^b Annual averages for wet and dry seasons, 1985/86.

Table 39—Sources of calories consumed in sinkiros, by expenditure quartile, wet season 1985

Source of Calories	Per Capita Expenditure Quartile of Sinkiros ^a				Total Average
	Lowest	Second	Third	Highest	
	(percent of total calories consumed)				
Rice	68.6	70.1	63.2	59.1	65.2
Millet, sorghum	8.7	3.7	6.1	8.5	6.8
Maize	2.4	0.8	3.5	1.3	2.1
Total cereals	79.7	74.6	72.8	68.9	74.1
Groundnuts	6.4	6.8	7.8	8.7	7.4
Sauce ingredients	1.0	0.8	0.8	1.1	0.9
Vegetables	1.5	1.2	1.1	1.0	1.2
Oil	1.6	3.2	4.2	4.9	3.5
Fish	2.4	3.1	2.6	3.1	2.8
Meat	0.9	2.2	2.4	3.2	2.2
Milk	2.0	2.6	2.6	2.5	2.4
Sugar	4.4	5.5	5.2	5.8	5.2
Other	0.1	0.1	0.7	0.9	0.5
(Average calories/day/adult-equivalent person)	(1,973)	(2,324)	(2,741)	(2,860)	(2,477)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a A *sinkiro* is a cooking and consumption group within a compound.

Table 40—Sources of calories consumed in sinkiros, by expenditure quartile, dry season 1986

Source of Calories	Per Capita Expenditure Quartile of Sinkiros ^a				Total Average
	Lowest	Second	Third	Highest	
	(percent of total calories consumed)				
Rice	40.3	52.2	42.3	49.7	46.2
Millet, sorghum	33.0	22.9	26.5	18.7	25.2
Maize	1.9	1.9	1.8	2.6	2.1
Total cereals	75.2	77.0	70.6	71.0	73.5
Groundnuts	14.3	10.6	15.2	12.7	13.2
Sauce ingredients	0.8	0.8	0.8	0.8	0.8
Vegetables	0.6	0.7	0.7	0.7	0.7
Oil	1.7	2.3	3.6	3.8	2.9
Fish	2.6	2.8	2.5	3.1	2.8
Meat	1.6	1.3	1.9	2.3	1.8
Milk	0.6	0.7	0.7	0.7	0.7
Sugar	2.6	3.6	3.6	4.3	3.5
Other	0.2	0.2	0.3	0.5	0.3
(Average calories/ day/adult-equivalent person)	(2,261)	(2,387)	(2,952)	(3,045)	(2,663)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a A *sinkiro* is a cooking and consumption group within a compound.

a higher share of their calories in the form of rice in the wet season. In the dry season, the picture is more diverse, but rice in this area is certainly not a rich people's grain. Millet and sorghum consumption is down to a share of 7 percent of calories in the wet season, but accounts for 25 percent in the dry season. Groundnuts emerge as a major food crop, providing an even higher share of calories than millet and sorghum in the wet season (7.4 percent) and 13.2 percent in the dry season. In the wet season, groundnut consumption shows a positive relation to income, but this is not the case in the dry season. All other foods (apart from cereals and groundnuts) provide 16 percent of calories consumed in the *sinkiros*. Sugar and oil dominate among these sources.

Substitution between Rice and Coarse Grains

The sample averages are biased toward rice growers because of the location in which the survey was carried out and the survey's task of assessing the effects of technological change and commercialization of rice production. A designation of villages by location in Table 41 provides information that is more generalizable for The Gambia. The villages outside the project area are lowland villages not affected by the project, and the upland villages were little affected by it. Still, rice is the main calorie source in all these groups of villages, especially in the wet season. In the dry season, upland village groups consume 42 percent of their calories from millet and sorghum before moving to purchased rice when their millet stocks are exhausted (Table 42). In none of the villages does rice provide less than 44 percent of all calories in the wet season, while village averages range between 16 and 67 percent in the dry season. These findings on food consumption patterns suggest for food policy that a focus on rice may be quite sensible, as rice is of vital importance in the diet, especially for the poorest segments of the rural Gambian population. Differences in these cereal consumption patterns by household appear to be largely driven by local and household-level availability. Households readily substitute between the two major types of cereals—rice and millet/

Table 41—Sources of calories consumed in households in project and nonproject villages, by season, 1985/86

Source	Wet Season 1985			Dry Season 1986		
	Lowland Villages	Upland Villages	Villages Outside Project (Lowland)	Lowland Villages	Upland Villages	Villages Outside Project (Lowland)
(percent of total calories consumed)						
Rice	71.6	53.0	71.2	58.8	25.3	46.7
Millet, sorghum	1.7	15.9	4.1	15.5	42.1	22.5
Maize	0.8	4.6	0.4	0.8	3.2	4.8
Total cereals	74.1	73.5	75.7	75.1	70.6	74.0
Groundnuts	5.0	12.5	4.0	9.5	19.8	11.3
Sauce ingredients	0.9	0.9	1.1	0.8	0.8	0.8
Vegetables	1.2	1.3	1.0	0.7	0.5	1.2
Oil	4.4	2.4	2.5	3.7	1.9	1.7
Fish	3.3	1.9	2.9	3.2	2.5	1.6
Meat	2.2	1.6	3.7	1.6	1.7	3.2
Milk	2.5	2.4	2.0	0.7	0.3	1.5
Sugar	6.0	3.5	6.8	4.4	1.8	4.5
Other	0.6	0.2	0.3	0.4	0.2	0.3
(Average calories/day/adult-equivalent person)	(2,386.0)	(2,656.0)	(2,390.0)	(2,589.3)	(2,900.7)	(2,321.6)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Parts may not add to totals because of rounding.

sorghum—within the year. This is visible at the village level, too. Millet and sorghum are the dominant sources of calories in the dry season in four of the eight participant villages. In these villages seasonal consumption switches between coarse grains and rice. In Sinchou Abdou, for instance, the rice share of calories moves between 67 percent and 27 percent in the wet and dry seasons, respectively, and in Sare Samba Sumali, between 78 percent and 25 percent. The villages that grow more rice also mainly eat rice year-round. Pacharr, Dasilameh, and Sukurr are such cases, with low shares of millet and sorghum consumption—from 0.1 percent to 11.0 percent between seasons. These villages have the highest access to project rice land by virtue of their status as traditional rice growers.

Consumption patterns throughout a season seem to be driven by availability, which is in turn determined by labor productivity in alternative grains. Enhanced supply of upland cereals, possibly as a result of yield-increasing technology, would face minimal demand constraints according to current consumption behavior. Replacing rice, especially in the dry season, appears to be fairly straightforward in this rural setting. However, the substitution of coarse grains for rice may be lower in urban areas of West Africa (Reardon, Delgado, and Thiombiano 1987). Price ratios and the time involved in food preparation (pounding millet takes considerably longer than pounding rice) do, of course, also affect the demand for millet and sorghum in rural areas, but mainly in the wet season when cash is less available and women's time more scarce.

If labor productivity in rice is increased by the rice project, consumption will shift more toward rice in households that have access to the new technology. Local trade does not level out the differences in availability by type of cereal crop over the seasons. To a large extent, one eats what one has grown. Limited trade of cereal-for-cereal takes place. There appears to be little desire to have a more frequent change in the cereal diet. When the millet-growing compounds have nearly exhausted their millet stock,

Table 42—Major sources of calories, by village and season, 1985/86

Village	Wet Season 1985				Dry Season 1986			
	Total Calories/ Adult-Equivalent Person/Day	Rice	Millet, Sorghum	Ground- nuts	Total Calories/ Adult-Equivalent Person/Day	Rice	Millet, Sorghum	Ground- nuts
		(percent of total calories)				(percent of total calories)		
Lowland villages in project								
Pacharr	2,372	75.6	0.1	5.0	2,748	65.5	11.1	8.2
Dasilameh	2,346	65.4	1.3	4.5	2,230	66.6	5.1	6.8
Sinchou Abdou	2,537	67.3	10.7	7.3	2,352	27.3	46.5	19.6
Sare Samba Sumali	2,450	78.2	1.1	4.1	3,404	25.3	47.0	16.7
Upland villages in project								
Njoben	2,603	44.1	20.8	15.8	2,719	16.1	56.1	19.3
Kussalang	2,875	65.9	16.8	4.0	3,492	24.2	35.4	21.8
Sukurr	3,176	59.5	3.6	16.5	2,811	46.5	1.8	20.2
Sare Bala	1,904	75.6	0.0	2.2	3,032	54.7	22.4	18.3
Villages outside project area								
Teneng Fara	2,608	66.9	6.3	4.4	2,579	38.7	28.8	11.1
Touba N'ding	2,134	75.8	1.6	3.6	2,018	56.0	15.1	11.5

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

they enter the market in the wet season, which implies the purchase of rice—identified in Chapter 5 as the primary traded cereal.

Effects on Calorie Consumption

A better understanding of the complex chain of links from technological change with commercialization through income to consumption can provide guidance on policy and programs for improved nutrition through agricultural development. The following analysis of the determinants of calorie consumption sheds further light on this.

A calorie-consumption model is specified and estimated separately for each of the two main seasons—wet (1985) and dry (1986). The dependent variable is the total calorie consumption per adult-equivalent person in each *sinkiro* (CALAE), which consists of the common *sinkiro* food and the snack food (derived from the recall surveys). Conventional demand theory leads to the hypothesis that calorie consumption is determined by income level (INCOME)—with a decreasing effect as income rises (INCOMESQ)—and market price of the major traded staple (RICEPR). Only the rice price, not other grain prices, is included in the model, because of the dominating role of rice and correlation with prices of other calorie-rich foods.

In the context of the marketed surplus model (Chapter 5), the problem of prices being potentially endogenous to type and scale of transaction and household income was alluded to. In the marketed surplus model, village mean prices were used because of variation of prices over the season. Seasonality is eliminated in this consumption model, as it is based on information covering one week in each season and the models are run separately for the two seasons. Intravillage price variation is larger than inter-village variation. An attempt was made to explain this price variability by household income, size of purchased quantity (scale effects), and distance to markets, which did not result in significant parameters for any of these variables. If there were endogenous relationships, a two-stage least square simultaneous estimation of price and quantity relationship would be called for. The observed price variability between households in the same village at the same time is due to factors such as discount transactions between relatives and friends inside or outside the village and acquisition of rice at different prices by household members traveling in the area or even to one of the distant cities. The actual price paid by the households was thus used in this calorie consumption model.

From larger *sinkiro* populations, positive scale effects due to less waste (SIZE) are expected in organizing food consumption, for instance. It is hypothesized that a higher share of cereals produced under women's control (WOMCER) has a positive consumption effect beyond the income effect of cereal production. This hypothesis is suggested by anecdotal indications that women's preference for spending income that they control on basic food is higher than men's. It would imply that women's *relative* loss of access to rice land leads to less-than-expected positive income effects of the new rice on consumption.

Somewhat related to this hypothesis, a test was conducted if an increased share of income in the form of cash (CASHIN) reduces the consumption of calories when income level is controlled for. This hypothesis is based on the notion that cash may end up in nonfood expenditure or purchased luxury foods to a larger extent than does subsistence food income. This may come about because of transaction costs and a different attitude of household members toward spending cash versus in-kind (food) income. It should be noted that much of the cash income is from groundnuts and comes in a lump sum.

It was further hypothesized that available food in storage (STORAGE), in the context of expected annual current income, determines offtake and thus calorie consumption,

especially in the wet season. Storage levels relate very little to income, as described in Chapter 5 (Table 27). Wet-season storage levels are largely determined by access to fully water-controlled rice in the project (apart from some large millet farmers).

Due to the apparent local differences in consumption, a variable was introduced that separates the lowland from the upland villages (LOCATION).

The per capita consumption information that forms the dependent variable involves knowing how many people attended *sinkiro* meals. As described above, the number of adults and weaned children eating each meal was recorded. When calculating "adult equivalents," a child was counted as 0.762 of an adult (men = 1, women = 1). Thus, for the calories-per-adult-equivalent variable—other than for the demographic structure of the compound personnel aggregated into adult equivalents used elsewhere in this analysis—a simpler weighting of persons had to be applied. The adult equivalents so formed are somewhat crude, but as many *sinkiros* were large, more detailed records of the age and sex of persons attending each meal was impracticable. To correct for further differences in demographic composition, (j) variables representing the population of the *sinkiros* (DEMOGR) were included at the beginning of each survey round. This allows accounting for variations both in the total size and in the precise age and sex composition of individual *sinkiros*. The analytical approach chosen here has the advantage that it is left up to the estimation procedure to determine differences from norm data whose applicability to the location remains questionable.²⁸ The stated hypotheses lead to the following model specification with each *sinkiro* (i):

$$\begin{aligned} \text{CALAE}_i = f(\text{INCOME}_i, \text{INCOMESQ}_i, \text{RICEPR}_i, \text{STORAGE}_i, \\ \text{WOMCER}_i, \text{CASHIN}_i, \text{LOCATION}_i, \text{DEMOGR}_{ij}). \end{aligned} \quad (16)$$

The model results are presented in Table 43. The following findings can be highlighted:

1. Calorie consumption is significantly income elastic, but with increased income the increase in calorie consumption is reduced, as indicated by the negative parameter estimated for the squared income term. The role of income for calorie consumption is more pronounced in the hungry season. A 10.0 percent increase in total annual income—at sample means—leads to a 4.8 percent increase in wet-season calorie consumption, but to only a 3.7 percent increase in calorie consumption in the dry season, when most households are well supplied with food.

2. An increased rice price, which stands for an index of cereal price, reduces calorie consumption as expected. In the wet season, a 10.0 percent price increase would reduce calorie consumption by 2.6 percent. The increased supply of rice due to technological change, with its likely price-depressing effect, can therefore be expected to have favorable consumption effects due to the price effect.

3. A reduced share of cereals from women's production reduces calorie consumption significantly in the wet season. Thus the shifting of women's *kamangyango* (private crops) and female-controlled *maruo* (communal crop) to the control of the compound head leads to reduced calorie consumption once income levels are controlled for.

²⁸ On the basis of a detailed activity survey in the village of Keneba (The Gambia), Roberts et al. (1982, 668-678) found that during the dry season lactating women were active 55 percent of the working day. In the early rainy season, this figure increased to 92 percent. For pregnant women, it was observed that activity increased from 50 to 83 percent in the rainy season.

Table 43—Calorie consumption models for wet and dry seasons

Variable*	Wet Season		Dry Season	
	Parameter	t-Value	Parameter	t-Value
INCOME	1.59329	7.218	0.94939	3.341
INCOMESQ	-2.067E-04	-5.316	-4.43508E-05	-0.853
RICEPR	-572.59043	-1.590	-635.95121	-2.030
STORAGE	4.26204	1.702	0.39015	0.464
WOMCER	321.83780	2.088	-57.30427	-0.264
CASHIN	67.74398	0.444	556.30173	1.707
LOCATION	-360.16405	-3.721	-319.89069	-1.994
SIZE	-16.89481	-1.149	-36.76049	-3.374
WOMSH	817.08670	1.823	1,478.36650	3.536
CHLD5SH	624.70833	1.038	553.32630	0.961
CHLD10SH	834.17860	1.812	626.22141	1.277
CHLD14SH	981.11329	1.867	1,364.50750	2.187
Constant	1,616.86638	2.937	2,755.13502	3.612
R ²	0.37		0.37	
F-value	9.65		9.72	
Degrees of freedom	197		197	

Notes: Dependent variable—calorie consumption per adult-equivalent person per day in respective season. A *sinkiro* is a cooking and consumption group within a compound.

* Definitions of variables:

- INCOME = total expenditure (as income proxy) per adult-equivalent person for year 1985/86 (in dalasi);
- INCOMESQ = income squared;
- RICEPR = rice price in dalasi/kilogram actually paid for purchases by household (if no purchase, village mean price of season);
- STORAGE = storage of all grains (in rice equivalents) per adult-equivalent person in respective season;
- WOMCER = share of cereals produced in *sinkiro* under women's control: 1985 wet-season estimation uses harvest from 1984 wet season and 1985 dry season; 1986 dry-season estimation uses 1985 wet-season harvest;
- CASHIN = share of cash income over total income earned by *sinkiro* in respective season;
- LOCATION = dummy variable = 1, if lowland village (else = 0);
- SIZE = size of *sinkiro* in adult-equivalent persons;
- WOMSH = share of women in adult-equivalent persons;
- CHLD5SH = share of children under 5 years of age in adult-equivalent persons;
- CHLD10SH = share of children 5-10 years of age in adult-equivalent persons; and
- CHLD14SH = share of children 10-14 years of age in adult-equivalent persons.

Maintained or expanded control by women of the cereal crop (rice) when production increases with new technology would have a beneficial effect for calorie consumption. If beneficial net effects for calorie consumption are to be achieved, given the changes in crop control, the income growth from technological change in rice must be higher to compensate for this adverse intrahousehold effect. A drop of women's share in cereal production from 30.0 percent (the sample mean) to 10.0 percent (the share in many *sinkiros* with pump-irrigated rice in the project) would, holding income constant, reduce per capita calorie consumption by 64 calories per adult equivalent, or 2.2

percent in the wet season. (The effect is not significant in the dry season when supplies are high.) To compensate for this with a higher income—given the estimated income elasticity of calorie consumption—would require an increase of 4.6 percent in income. This is much less than the income increase of about 13.0 percent estimated earlier that is due to the new technology in lowland villages. The relative diversion of income from calories after women lose control of rice is therefore less than the favorable effect for calorie consumption deriving from a higher total household income. The trade-off exists, however, and although clearly recognized as a net improvement on average, may not always bring this result.

4. An increased share of cash income does not, as hypothesized, reduce calorie consumption once income is controlled for. In the dry-season model, it turns out to be just significantly positive. More cash income in total income increases calorie consumption beyond the income effect (it should be noted that the cash share in total income is not correlated with total income [$r = -0.005$]). In the wet-season model, no significant effect of cash income beyond total income is found. More cash income does find its way into calories for the *sinkiro*, and these are to some extent in the form of snack foods. Increased monetization of the economy in this West African setting does not appear to be adverse for food consumption.

5. Larger *sinkiros* consume significantly less per adult-equivalent person. In a *sinkiro* with 20 adult equivalents versus one with 10, every adult (equivalent) person uses 5.8 percent fewer calories in the wet season and 11.7 percent fewer in the dry season. One interpretation suggests that these are the favorable effects of economies of scale. However, an alternative interpretation can be that in larger *sinkiros* various subgroups of the family may not obtain as much food as in smaller *sinkiros*. Children may end up more neglected. This hypothesis is tested further in the following nutritional status analysis.

6. The demographic variables show that the variable representing women's share in the number of adult equivalents in the household is positively significant. This is so even though women were weighted equally to men in the adult-equivalent count of meal participants. One likely interpretation of this is that in *sinkiros* with a high proportion of women there is more female labor available for food preparation and more food is, therefore, prepared and subsequently eaten. Another interpretation is that women, with their relatively heavy energy expenditure and easy access to the kitchen, actually do need and eat more than men.

At higher income levels, *sinkiros* spend absolutely and relatively more on expensive food items, such as meat and palm oil (see Table 33). This means that the per calorie cost of the diet rises. The differences between income groups are particularly pronounced in the wet season, when the poor economize on consumption by a switch to a lower-cost diet, a tendency that is less usual among higher-income groups. In the wet season, the lowest quartile spend 31 percent less per calorie than the top quartile as a result of dietary choices, but in the dry season, only 21 percent less (Table 44). Spending per 1,000 calories increased from D0.66 to D0.99 between the two seasons, which partly reflects price inflation (the average rice price went up from D1.33 to D2.05 per kilogram) and partly is the consequence of a change in diet composition. In the poorest quartile the unit cost of calories increased by 66 percent from wet to dry season (which is 8 percent more than the rice price increase). In the top quartile, the per calorie cost increase was 44 percent. Thus it is the lower income groups that bear the main burden of adjustment to (seasonal) price and income fluctuations (see also Table 35).

Table 44—Unit cost of calories, by income quartile and season, 1985/86

Income Quartile*	Unit Cost per 1,000 Calories Consumed by Group		Increase from Wet Season to Dry Season
	Wet Season 1985	Dry Season 1986	
	(dalasi)		(percent)
Lowest	0.56	0.93	66.1
Second	0.60	0.91	51.7
Third	0.65	0.94	44.6
Highest	0.81	1.17	44.4
Average	0.66	0.99	50.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

* Expenditure is used as a proxy for income.

NUTRITIONAL EFFECTS

Children in The Gambia are considerably affected by malnutrition. There are complex interactions between seasonality in food production, health environment, mothers' activity patterns, food availability, and household income that affect child nutrition. The chain that leads to high prevalence rates of malnutrition and high mortality rates among children begins with low birth weights and early growth faltering due to an adverse health environment and their mothers' time constraints in the wet season. The low birth weights result from increased stress on pregnant women due to high energy expenditures (at peak of fieldwork) and low intakes in the wet season. Similarly, seasonal energy stress reduces breast milk production, which then reduces weight gains in older babies (Prentice 1980, 167-183). Toddlers and children are affected by the quantity and quality of food available and by the frequency of meals served in the *sinkiros*. For them, household-level calorie availability may be of more direct relevance for nutritional status than the indirect effects of income generation and the nutrition and health status of mothers and caretakers.

Separating the actual effects of unsatisfactory food consumption from health problems (such as infectious diseases and diarrhea) remains difficult. It is probably their dynamic interaction, rather than a clearly separable cause and effect chain, that leads to the worrying nutritional deterioration of many children by the age of two years. The cross-sectional analysis that was performed on the basis of the survey has obvious limitations in capturing the dynamic interactions of health and nutrition.

As Payne (1987, 37) stresses:

For very young children, a major environmental stress is infectious disease. These not only induce some of the same kinds of physiological adjustments as direct food deprivation; they actually cause undernutrition by reducing appetite. Both together can produce changes in growth control mechanisms which are largely irreversible, resulting in major adjustments in body size of whole populations, the health implications of which are at present little understood, but which are only changeable over periods of generations.

Better understanding of the health-nutrition relationship is crucial for public policy aimed at improving both the household food and health entitlements. To further quote Payne on this issue:

At the level of the household, resource allocation decisions which take account of the child's need ought, however, to be based on a better understanding of the linkages between those two entitlement sets, and of the pivotal role of women (generally, not only mothers) in those decisions. Combining together the outcome of food deprivation and disease, as if these causes were interchangeable and indistinguishable, will not help in deciding for example whether women's labor time is better deployed in earning cash for more food, or controlling the disease transmission environment in the home, or spending time administering oral rehydration therapy.

Nutrition and Health in The Gambia and the Survey Area

No representative countrywide data on the prevalence of child malnutrition is available for The Gambia. The best alternative is data from growth monitoring by

Catholic Relief Services (CRS) of children participating in CRS nutrition schemes. Data for 1985 suggest that, according to the season, 33-45 percent of the children in the programs were below 80 percent of reference standard weight-for-age (Table 45).²⁹ As the program makes an attempt to target malnourished children—and does to some extent achieve this (Gambia 1985c)—the figures presented are probably higher than the actual national prevalence of malnutrition. The relative regional distribution of the CRS figures indicates an above-average prevalence in MacCarthy Island Division, which is the area of the IFPRI/PPMU survey.

Methods of Anthropometry Survey

The nutrition data of the IFPRI/PPMU survey are based on weight and height measurements of children under the age of 10 and their mothers. Age was carefully identified for those children who did not have a clinic card or other birth-date record. However, for children older than 6 years who had no record, age recall was sometimes problematic. All children in the survey population were measured once in the wet season (August-September 1985) and once in the dry season (February-March 1986) with the help of length-boards. Weights were taken at the same time. Height measurements were made with stachometers or length-boards (for those less than 24 months of age). Weight measurements were made with hanging scales (for children) or "bathroom" scales (for women). All measurements were made within the household by a

Table 45—Prevalence of malnutrition in The Gambia, by region and season, 1985

Region	Children Aged 0-5 Years Monitored by CRS*	Children Below 80 Percent of Weight-for-Age Among Those in CRS Schemes			
		January- March	April- June	July- September	October- December
		(percent)			
Western Division	15.1	25.0	27.0	32.0	37.0
Lower River Division	31.4	34.0	35.0	36.0	44.0
North Bank Division	29.4	34.0	32.0	39.0	47.0
MacCarthy Island Division	10.6	41.0	44.0	48.0	53.0
Upper River Division	12.9	36.0	39.0	36.0	47.0
Country average	14.8	33.0	34.0	38.0	45.0

Source: The data were provided by the Banjul office of Catholic Relief Services in a more disaggregated tabulated form.

* CRS = Catholic Relief Services.

²⁹ Field surveys such as the IFPRI/PPMU survey normally use weight and height (on their own or related to age) to describe anthropometric status. Height-for-age is a long-term measure of a child's nutrition and health experience, since it represents total growth achieved. A "stunted" child is one who is short for his age (that is, one who has grown inadequately). Weight-for-age reflects the total growth history of the child, but since weight can be rapidly lost (or gained), it is also influenced by the child's recent nutrition and health experience. Weight-for-height is usually considered the measurement that best expresses the child's present nutritional situation. The thin or "wasted" child is regarded as showing evidence of recent nutritional deprivation. These anthropometric measurements are compared with those found in a standard "reference" population (where food is freely available and health is good). Malnutrition is said to occur in those individuals whose measurements fall below defined cut-off points when compared with these standards. In the case of weight-for-age, children below 80 percent of standard are commonly classed as at least moderately malnourished (those below 60 percent are classed as severely malnourished).

specially trained and supervised team. Child identification was verified by enumerators familiar with the compounds.

Information on the structure and prevalence of malnutrition in the survey population is presented in this chapter. Thereafter, this information will be related to the technological change in rice production in a descriptive account. Subsequently, in multivariate analyses, an attempt will be made to explain differences in the nutritional status of children in order to identify efficient ways of improving nutrition and to clarify the potential role of agricultural development in this context.

For much of the presentation, the concept of "Z-scores" is used to express the extent to which a child's anthropometric measurements (weight-for-age, height-for-age, weight-for-height) deviate from median or average age-specific measures in a reference population. The Z-score is computed as follows for each child's observation:

$$\frac{\text{Actual child's measure} - \text{reference value}}{\text{Standard deviation of reference population}}$$

A Z-score of zero is "normal," although one must also allow for normal individual variation around that norm. Conventionally, a Z-score value of below minus 2 is considered malnourished. The World Health Organization/National Centre for Health Services standards are used here as references.

Nutritional Status in the Sample Population

The average values of Z-scores of the sample population show that children start on average with a normal weight, but that weight deteriorates rapidly in the 7-to 12-month age group, especially in the wet season (Table 46). This deterioration continues so that children of weaning age (13-24 months) have average Z-scores of -2. In fact, 50.7 percent of them are below -2. In this age group, a considerable degree of stunting prevails (see height-for-age, Table 46), combined with wasting (see weight-

Table 46—Nutritional status of children, by age group as measured by Z-scores, 1985/86

Age Group	Number of Observations		Height-for-Age Dry Season	Mean Values of Z-Scores			
	Wet Season	Dry Season		Weight-for-Age		Weight-for-Height	
				Wet Season	Dry Season	Wet Season	Dry Season
(months)							
1-6	46	39	0.07	-0.07	0.61	0.10	0.55
7-12	51	39	-1.40	-1.58	-1.19	-1.14	-0.11
13-24	75	80	-1.80	-2.02	-1.52	-1.33	-0.60
25-60	241	201	-1.39	-1.41	-1.33	-0.62	-0.57
61-120	299	284	-0.51	-0.90	-0.72	-0.78	-0.58
Totals							
1-120	712	643	-0.96	-1.17	-0.95	-0.75	-0.47
1-60	413	359	-1.33	-1.37	-1.15	-0.74	-0.41

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

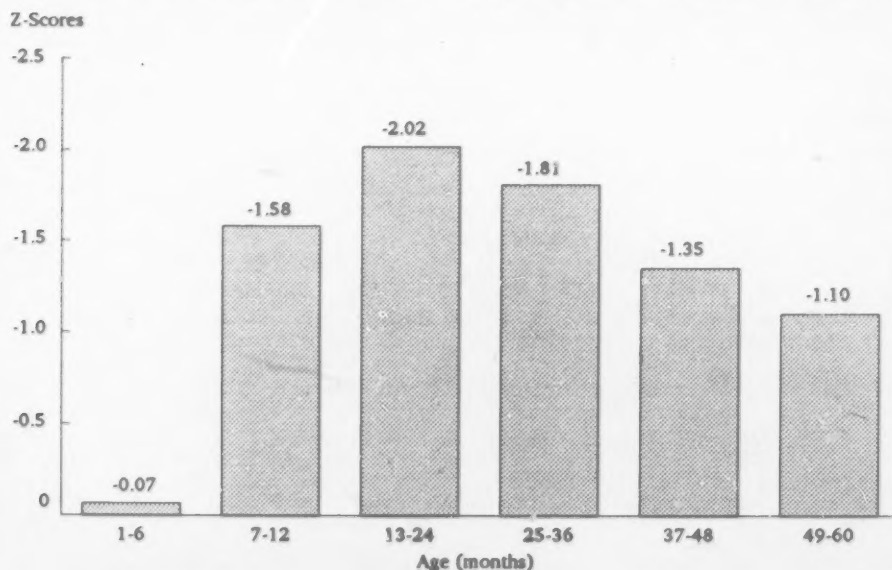
Notes: Wet-season data are for August-September 1985 (preharvest "hungry season"). Dry-season data are for March 1986.

for-height in Table 46). The situation appears to improve as children grow older (Figure 6), but this interpretation of the relative improvement in Z-score values after the age of 13-24 months may be misleading. Children with a particularly high degree of malnutrition are more likely to die at a young age, thus the average Z-score figure for the surviving children may rise. For instance, the average weight-for-age Z-score value of the 10 children (7-30 months of age) who died between the two survey rounds (July/September 1985-March 1986) was -2.98 in the first round, indicating very serious undernutrition, while the general average was -1.86 for this age group.

The percentage of malnourished children is higher in the wet season than in the dry season. In the wet season, 35 percent of the children aged 1-60 months were below 80 percent of the standard weight-for-age (Table 47). Those aged 7-24 months not only had the highest proportion of malnourished children but also showed the greatest seasonal variation. Children who are born late in the dry season or early in the wet season show a much worse nutritional status than children born at other times (Table 48). These "start conditions" of children determine their growth performance throughout their childhood. Significantly fewer children (by 24 percent) born in the "bad" season are among the living children in the sample. This may be partly a result of higher mortality of children born in this season. It may also be partly a result of planned seasonal birth spacing, or simply the result of seasonal patterns of leisure and pleasure. It is clear, however, that seasonality has profound implications for nutritional status. Given the rice project's effect on seasonal food supply and income, a positive effect might also be expected in the realm of nutrition.

In general, nutritional status is better in the dry season than in the wet season. This is especially true where weight-for-height indicators are concerned. However,

Figure 6—Weight-for-age of children aged 1-60 months, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Table 47—Prevalence of malnutrition of children, by age group

Age Group (months)	Height-for-Age, Dry Season, Less Than 90 Percent	Weight-for-Age				Weight-for-Height	
		Wet Season		Dry Season		Wet Season	Dry Season
		Less Than 60 Percent	Less Than 80 Percent	Less Than 60 Percent	Less Than 80 Percent	Less Than 80 Percent	Less Than 80 Percent
		(percent of children less than — percent of median)					
1-6	2.6	...	10.9	...	5.1	...	...
7-12	10.8	2.0	51.0	2.6	28.2	19.6	2.6
13-24	21.3	5.3	52.0	2.5	32.5	7.9	2.5
25-60	16.9	1.2	31.0	0.5	27.3	3.7	1.5
61-120	5.2	1.0	25.7	...	16.3	4.3	1.4
Total 1-120	10.9	1.5	31.1	0.6	21.1	5.3	1.5
1-60	15.6	1.9	35.0	1.1	26.3	6.0	1.7

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

there are differences between villages. For instance, Njoben and Kussalang (two upland villages) show substantially less seasonal fluctuation in children's nutritional indicators than Pacharr or Dasilameh (two lowland villages highly involved in the project (Table 49)). Njoben and Kussalang were identified earlier as comparatively "rich" villages with high levels of food consumption. This may indicate that at high income levels the pronounced seasonal production fluctuations in upland villages are coped with more easily and have a limited effect on children's nutritional status.

This indication is supported by the nutritional data organized by income levels of households in Table 50. Especially the more long-term indicators of nutritional status (height-for-age and weight-for-age) are positively related to income level, and particularly for those aged 5-10 years. Seasonal differences tend to be higher among the poor. Overall, however, the results are hard to interpret in monocausal ways, given the host of factors affecting nutritional status. More refined approaches will therefore be applied to trace the income-consumption-nutrition relationships in regression analyses below.

With more rice land in the new project, the proportion of stunted children (low height-for-age) is smaller (Table 51). As far as weight-for-age is concerned, however, in the wet season greater access to the project's rice land is not associated with improved nutritional status. In both seasons, the highest proportion of children with poor weight-for-height was in the group with no project rice. It is clear that the data in Table 51 cannot be easily interpreted as a cause (project) and effect (nutrition) relationship. More rice land in the project may have various implications for the different factors

Table 48—Nutritional status of children aged 1-60 months, by season of birth

Indicator	Average Z-Score Values	
	Born During September- February ^a	Born During March- August ^b
Weight-for-age	-1.46	-1.72
Height-for-age	-1.22	-1.63
(Number of observations)	(204)	(156)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Late wet season and early dry season.

^b Late dry season and early wet season.

Table 49—Nutritional status of children aged 6-59 months, by village and season, 1985/86

Village	Average Weight-for-Height Z-Scores of Children 6-59 Months		Average Weight-for-Age Z-Scores of Children 6-59 Months	
	Wet Season	Dry Season	Wet Season	Dry Season
Lowland villages in project				
Pacharr	-0.99	-0.54	-1.60	-1.39
Dasilameh	-0.84	-0.59	-1.60	-1.34
Sinchou Abdou	-0.75	-0.54	-1.60	-1.35
Sare Samba Sumali	-0.92	-0.46	-1.35	-1.37
Upland villages in project ^a				
Njoben	-0.75	-0.70	-1.51	-1.55
Kussalang	-0.48	-0.46	-1.34	-1.18
Sukurr	-1.38	-0.43	-1.72	-1.22
Villages outside project area (lowland)				
Teneng Fara	-0.73	-0.77	-1.22	-1.19
Touba N'ding	-0.39	-0.23	-1.79	-1.59
Total average	-0.81	-0.57	-1.56	-1.41

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a The village of Sare Bala is not included here because of limited numbers of observations.

that influence nutritional status. Income may rise and food availability may increase, thus a potential for improved nutrition is there. On the other hand, mothers' time may be more constrained and child-care quality may suffer due to work load. Also, small children carried more frequently to the project fields by their mothers may be exposed more to malaria. This project uses ponded water, which in some situations presents a health hazard. The net effect of such factors will be addressed in the model analysis below, which also tests for the statistical significance of the apparent differences diagnosed

Table 50—Prevalence of malnutrition among children, by household income level and season, 1985/86

Indicator	Age Group	Season	Income Quartile ^a				Average
			Lowest	Second	Third	Highest	
			(percent of children)				
Less than 90 percent Height-for-age	6-59	Wet	30.1	13.8	13.1	14.3	17.1
Less than 80 percent Weight-for-age	6-59	Wet	40.5	37.9	36.9	39.3	38.5
Weight-for-age	6-59	Dry	28.3	30.1	36.3	20.8	28.8
Weight-for-height	6-59	Wet	9.3	6.0	5.9	7.1	6.9
Weight-for-height	6-59	Dry	5.7	1.0	2.7	0.0	2.0
Less than 90 percent Height-for-age	60-120	Wet	11.0	5.6	7.7	3.0	6.9
Less than 80 percent Weight-for-age	60-120	Wet	32.8	29.2	24.3	15.2	25.8
Weight-for-age	60-120	Dry	16.7	19.0	20.6	10.5	16.7
Weight-for-height	60-120	Wet	4.1	5.6	2.6	4.6	4.3
Weight-for-height	60-120	Dry	0.0	1.3	2.7	1.3	1.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Total expenditures per capita per year is used as an income proxy.

Table 51—Prevalence of malnutrition among children aged 6–59 months, by access to project land and season, 1985/86

Indicator	Season	No. Project Rice Land	Level of Compound Access to Project Land*				Average
			Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	
(percent of children)							
Less than 90 percent Height-for-age	Wet	33.3	17.1	16.9	13.2	14.0	17.1
Less than 80 percent Weight-for-age	Wet	30.0	37.7	33.7	43.4	45.6	38.5
Weight-for-age	Dry	17.8	33.2	34.2	26.8	21.4	28.8
Weight-for-height	Wet	12.9	5.7	6.7	7.8	5.3	6.9
Weight-for-height	Dry	3.6	1.2	2.4	1.8	1.8	2.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a Pump-irrigated land equivalent per adult-equivalent person.

in the above tabulations. It is noteworthy that mean values and prevalence rates of nutritional status and malnutrition are not the only changes in association with socioeconomic and health-related variables—the whole distribution pattern also changes, as highlighted in Figure 7. The distribution of weight-for-age Z-scores of the child population from compounds with most access to new rice land is considerably shifted into the ± 1 Z-score area and no longer looks normally distributed.

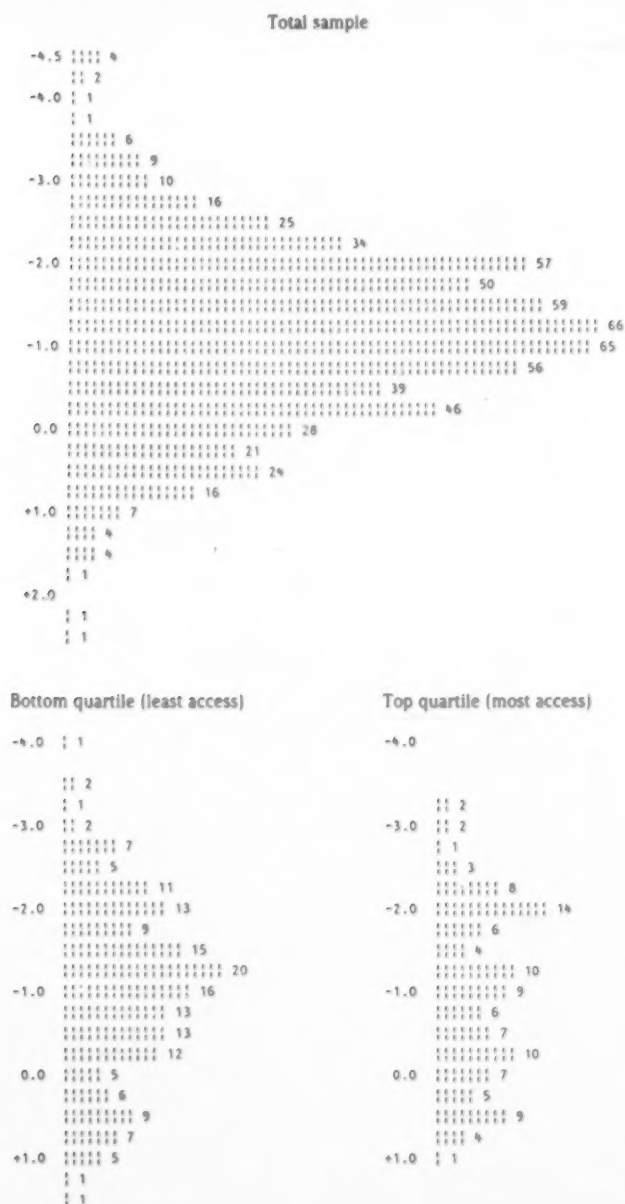
Prevalence of morbidity and mortality does not show a clear association with access to new rice land. Child mortality appears to decrease with access to more rice in the project. Diarrhea prevalence shows no difference between the top and bottom quartiles; fever (malaria), however, appears to increase. It should be noted that the population with most access to the project already lives close to the swamps, which are traditionally malaria-prone.

Mothers' Nutritional Status and Time Allocation

Mothers' health, activity patterns, and time allocation are of greatest importance for children's nutritional performance. To get an indicator of their nutritional status, the weights and heights of mothers were measured in the wet and dry seasons along with those of their children. Mothers were also interviewed about their own and each of their children's health (and health care), using a recall of symptoms and a record of types of treatment for the preceding four weeks. Also, a week's recall of mothers' allocation of time (time spent away from the compound) by type of activity was effected during each survey round.

Women's body weight fluctuates on average by at least 2.20 kilograms between the wet season and the dry season (Table 52). The fluctuation is about twice as high in absolute and relative terms in the upland villages as in the lowlands. Phillips, Coles, and Seaman (1982) found annual fluctuations in body weight of at least 3.46 kilograms for women, although the comparable figure for men was only 2.11 kilograms. This fluctuation in weight is a result of seasonal imbalances between the energy intake and energy expenditures of women. It has profound implications for children's health and growth performance. A reduction of this stress on mothers in the wet season by means of increased food consumption and reduced work load could be expected to have favorable effects not only for the mothers, but for their children as well, particularly the babies. With increased project involvement, women's weight fluctuations are reduced (Table 52).

Figure 7—Distribution of weight-for-age Z-scores of children aged 7-120 months, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Table 52—Nutritional status of mothers in the wet and dry seasons, by level of access to project land, 1985/86

Level of Access to Project Land	Change in Mean Weight from Wet to Dry Season	Weight-for-Height in Dry Season	Change in Weight-for-Height from Wet to Dry Season
	(kilograms)	(kilograms/100 centimeters)	(percent)
Lowest quartile	+ 2.9	34.6	+ 5.4
Second quartile	+ 2.6	33.5	+ 4.8
Third quartile	+ 1.7	33.2	+ 3.0
Highest quartile	+ 1.1	34.1	+ 1.8
Average	+ 2.2	33.9	+ 4.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Women's reduced weight stress over the seasons may be seen as a substantial benefit of the new technology in rice (that is, the second crop) that levels out seasonal fluctuations in production and, therefore, consumption. A look at women's activity patterns sheds more light on this.

Women from lowland villages spend more time away from the compound and a higher share of that time working in field crops than women from upland villages. Rice plays a dominant role in this pattern. In the wet season, lowland women worked 61.4 percent of their available work time away from the compound, and upland women, 47.1 percent. In that main cropping season, lowland women spent 70.5 percent of their time working outside the compound in rice and a total of 78.6 percent in crop production. Upland women, on the other hand, spent 9.3 percent of their time on rice and a total of 71.7 percent in crop production. Thus, lowland women (mostly Mandinka and Serahuli) work an average of 44.0 percent more in field crops than upland women (mostly Fula and Wolof).

With increased access to the rice project—which largely coincides with village location in lowlands—women spend more of their time away in the rice fields (for example, 16.2 percent in the lowest quartile and 74.1 percent in the highest quartile [Table 53]). Accordingly, an almost linear substitution occurs with upland crops in the wet season.

To a surprisingly large extent other activities also lead women to work away from the compound during the dry season when there are no crops in the upland fields. This results in a rather low degree of seasonality in total time spent away from the compound. Thus, women from compounds with greater access to rice land in the project spend equal amounts of overall work time away from home during both seasons. Work in project rice and upland cereals is balanced with nonfarm activities. That is, nonfarm activities almost completely substitute for the reduced labor demand from upland fields in the dry season (Table 53).

How does this time allocation affect child care? Information compiled in Table 54 shows that women from compounds with more rice land in the project tend to take their older children (above 18 months) less frequently with them to the field. However, the children remain attended, if only by older children and other women in the compound. The pattern changes in the dry season when women's time is less scarce; older women rather than older children are then the main caretakers when the mother is away. Apparently, child care by older children is the less-desired choice, but the work load in the wet season often leaves no other option. Also, in the dry season, babies are much less frequently

Table 53—Allocation of women's time away from the compound, by level of access to project land, 1985/86

Time Allocation	Level of Access to Project Land							
	Lowest Quartile		Second Quartile		Third Quartile		Highest Quartile	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
Time away from compound per week (in workday equivalents)	3.4	2.5	4.3	4.1	4.1	3.8	4.0	3.9
Time away from compound during day (in percent of a seven-day week)	48.6	35.7	61.4	58.6	58.6	54.3	57.1	55.7
	(percent of above time)							
Work in rice fields	16.2	6.5	51.9	54.2	61.4	62.3	74.1	61.1
Work in fields of upland crops (grains, groundnuts)	51.4	...	28.3	...	12.7	...	4.7	...
Other farming, vegetables	3.2	5.6	1.5	3.8	...	1.3	0.1	1.1
Other activities (such as fetching water, firewood, marketing)	29.3	87.9	18.3	41.9	25.9	36.1	21.1	37.8

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: Parts may not add to totals because of rounding.

taken by the mother, but rather are left at home. Provision of child-care facilities in the wet season would assist women in increasing their labor productivity.³⁰

Determinants of Nutritional Status and the Role of New Rice Production

If nutritional improvement is an objective of agricultural development, improved knowledge about the relationship between the two is of crucial relevance for appropriate program and project design. The following analysis attempts to explain children's nutritional status and its change in the context of food consumption and the health and sanitation environment of the compounds in which they live. The link to agricultural development (that is, rice) is established with the analyses in Chapters 5 and 6, in which the income and food consumption effects of technological change and commercialization were assessed (see also conceptual framework, Chapter 2, equation [8]).

The nutritional status variables to be explained in the model are Z-score values of (1) height-for-age, representing the more long-term result of food and health environment to which the child was exposed; (2) weight-for-age, representing an intermediate measure, as weight is also positively related to height (which is more a result of malnutrition and disease episodes in the past); and (3) weight-for-height, representing the short-term (acute) nutritional situation.

The explanatory variables of the model consist of four different blocks:

- Food consumption-related variables—
calorie consumption of the *sinkiro*

³⁰ Day-care centers located around the rice project were an attempt to fill this apparent need.

Table 54—Pattern of child care when mother was away from compound, by age of child and season, 1985/86

Child Care When Mother Was Away ^a	Age of Child (Months)					
	0-6	7-12	13-18	19-24	25-30	31-60
	(percent of children)					
Wet season						
Total sample						
Taken with her	68.9	41.2	37.5	31.4	13.2	21.7
Left with other women in compound	13.3	17.6	17.5	28.6	13.2	29.7
Left with other women in other compound	4.4	2.0	2.5	2.9	10.5	3.4
Left with father	...	...	5.0	...	2.6	1.7
Left with other children	8.9	39.2	35.0	34.3	55.3	29.7
Left on its own	...	...	2.5	2.9	2.6	11.4
Left with others	4.4	...	...	...	2.6	2.3
By access to new fields in project						
Taken with her						
Lowest quartile	58.3	37.5	70.0	66.7	33.3	46.2
Second quartile	66.7	43.8	11.1	18.2	11.1	25.0
Third quartile	60.0	28.6	30.0	33.3	...	7.5
Highest quartile	77.8	60.0	33.0	...	...	...
Dry season						
Total sample						
Taken with her	57.9	30.6	11.9	12.1	...	1.3
Left with other women in compound	23.7	35.9	52.4	57.6	75.0	42.7
Left with other women in other compound	2.6	2.6	2.4	9.1	...	4.0
Left with father	...	...	4.8	...	...	0.7
Left with other children	13.2	30.8	28.6	15.2	21.4	32.7
Left on its own	...	...	...	...	3.6	16.7
Left with others	2.6	...	...	6.1	...	2.0
By access to new fields in project						
Taken with her						
Lowest quartile	66.7	33.3	28.6	25.0	...	...
Second quartile	70.0	50.0	6.7	11.1	...	2.6
Third quartile	50.0	33.3	...	...	...	2.9
Highest quartile	60.0	28.6	...	...	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a During the week preceding the interview.

- Health- and sanitary-related variables—
 - prevalence of sickness (for example, diarrhea)
 - quality of village drinking water
- Demographic environment of household—
 - size of *sinkiro*
 - number of children in *sinkiro*
- Individual child's demographic characteristics and history—
 - sex
 - age
 - born in "bad" season
 - child of the compound head
 - mother's height

Besides these factors, account is taken of the accuracy of information obtained by controlling for data on birth dates actually documented versus those only estimated by the mother. Finally, an evaluation is made of whether the degree of participation in the new rice project has an effect beyond the determinants mentioned above. This is to test for secondary and indirect effects at work in the complex web of nutrition-consumption-health and child-care relationships. The data from both survey rounds are pooled in the model and separated by a dummy variable to account for seasonal effects besides those captured by the variables mentioned.

This leads to the model below, which is based on the following hypothesis. Increased per capita calorie consumption at the household level (CAL) also increases calorie consumption for children, who capture their own share of the greater availability. This increased consumption reduces the nutrition problem, but decreasingly so at the margin (CALSQ). If a child had diarrhea (DIAR) for an extended time preceding the survey date, its nutritional status has presumably deteriorated. An attempt is made to capture genetics (GEN) by mother's height (fathers were not included in the anthropometry survey). While short-term nutritional status is affected by diarrhea and related diseases, poor village water quality (WATER) is expected to have an adverse effect on the nutrition and health environment in which the child grows up. In large *sinkiros* (SIZE) and in *sinkiros* with a high share of small children (NCHILD), it is hypothesized that negligence in child care will have negative effects for child health and nutrition. On the other hand, it is hypothesized that children of the compound head (CHCHD) are better taken care of than others; the models test for differential nutritional performance of boys versus girls (SEX), and take account of the age-specific curvature of growth (AGE, AGESQ). As indicated by the earlier tabulations, it is hypothesized that children born in the "bad" season may suffer nutritionally (SBORN); from increased access to the rice project (RICPROJ), favorable income and consumption and, thus, nutritional effects are expected. These should be captured in the calorie consumption and in spending on health improvement. On the other hand, adverse effects are expected for women's income control and work load; time and income allocated to nutritional improvement may suffer because of that, and this effect—over and above the income consumption effect—is expected to be captured by the RICPROJ variable.

The model is thus as follows:

$$\begin{aligned} \text{NUTSTAT}_{i,s,r} = f(\text{CAL}_{s,r}, \text{CALSQ}_{s,r}, \text{DIAR}_{i,s,r}, \text{GEN}_{i,s,r}, \\ \text{WATER}_s, \text{SIZE}_s, \text{NCHILD}_s, \text{SEX}_{i,s}, \text{AGE}_{i,s,r}, \text{AGESQ}_{i,s,r}, \\ \text{SBORN}_{i,s}, \text{CHCHD}_{i,s}, \text{VERDAT}_{i,s}, \text{RICPROJ}_s, \text{DRYS}_r), \end{aligned} \quad (17)$$

where

VERDAT = verification of birthdate,
DRYS = observation in dry season,
i = child,
s = *sinkiro*, and
r = survey round (season wet, dry).

(For variables in general terms, see preceding text; for specific definitions, see Table 55.)

Explanatory power of this type of model in terms of R^2 is low, in general because of much variance in the dependent variables, which is due to genetics and the past health and nutrition history of children not captured in the cross-sectional analysis. It is more the levels and significance of estimated parameters that are telling. From the estimation results in Table 55, the following are highlighted:

Table 55—Determinants of nutritional status

Variable ^b	Weight-for-Age Z-Scores of Children Aged 7-120 Months ^a		Height-for-Age Z-Scores of Children Aged 7-120 Months		Weight-for-Height Z-Scores of Children Aged 7-120 Months	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
CAL	0.0091559	2.713	9.314474E-03	2.206	4.611568E-03	1.468
DIAR	-2.50525	-2.690	-4.05504	-3.480	-0.31224	-0.360
WATER	-0.01006	-2.248	-0.02183	-3.897	4.735614E-03	1.136
SIZE	-0.71560	-1.826	0.62056	1.266	-1.38726	-3.802
NCHILD	-0.10040	-0.547	-36.18402	-1.739	17.92066	1.157
SEX	-8.18773	-1.501	-18.33278	-2.685	1.84985	0.364
AGE	1.67620	4.308	0.72466	1.488	0.92144	2.543
AGESQ	-7.69439E-03	-2.426	1.513454E-03	0.381	-6.64467E-03	-2.250
SBORN	-13.64637	-2.480	-18.33008	-2.662	-3.49221	-0.682
GEN	1.85207	4.487	2.52886	4.896	0.22410	0.583
CHCHD	17.84216	3.074	14.89253	2.050	15.53760	2.874
VERDAT	-19.99746	-3.132	-34.58969	-4.329	4.81197	0.809
RICPROJ	-109.19153	-0.740	-110.01574	-0.596	-45.46775	-0.331
DRYS	19.29197	3.507	-0.69184	-0.101	26.61881	5.197
Constant	-467.02280	-6.746	-507.38817	-5.857	-160.14683	-2.484
R ²	0.164		0.162		0.072	
F-value	17.28		17.06		6.88	
Degrees of freedom	1,233		1,233		1,233	

^a Z-scores are multiplied by 100 in this analysis.

^b Definitions of variables:

CAL	= calories per adult-equivalent person per day from all sources, including snacks;
DIAR	= number of days of diarrhea in preceding four weeks;
WATER	= bacteria count of most-used well in village used for drinking water;
SIZE	= number of adult-equivalent persons in <i>sinkiro</i> (cooking and consumption group);
NCHILD	= number of children under 10 years of age over number of persons in <i>sinkiro</i> (ratio);
SEX	= sex of child (= 1, boys; = 0, girls);
AGE	= age of child in months;
AGESQ	= age of child in months squared;
SBORN	= If child born in "bad" season (March-August) (= 1, else = 0);
GEN	= height of mother in centimeters;
CHCHD	= If child is son or daughter of compound head (= 1, else = 0);
VERDAT	= If date of birth is verified by record (= 1, else = 0);
RICPROJ	= size of lands in new rice project in hectares of irrigated land equivalent per adult-equivalent person; and
DRYS	= If observation in dry season (= 1, else = 0).

• Increased food energy consumption reduces children's nutrition problem as expected.³¹ A 10 percent increase in calorie availability per capita in the *sinkiros* significantly increases the weight-for-age Z-score at the sample mean by 0.28 (2.4 percent). Increased calorie availability clearly has a very favorable effect for children's nutritional improvement. The respective elasticities of Z-scores with respect to calories are high

³¹ No significantly decreasing effect is found at the margin. The specification was therefore changed and CALSQ was dropped.

for all three nutritional status indicators. They range between 0.24 and 0.26 for the three indicators calculated at sample means.

- High prevalence of diarrhea is associated with a reduction in nutritional status. This is significant for height-for-age and weight-for-age, although not for weight-for-height. The latter part of this finding is curious, since one would expect the prevalence of diarrhea measured during the survey to have the greatest effect on the short-term indicator and less effect on the long-term anthropometric characteristic of the child. It may be, however, that the diarrhea variable represents underlying unhygienic conditions in the home.

- Children from villages with unclean drinking water—that is, where a high bacteria count was found in the water sample—were significantly more stunted (see height-for-age model). Frequent episodes of water-borne diseases can be assumed to be the cause of this.

- The parameter of mother's height, which is seen as a genetic indicator, contributes to explaining child's height-for-age and weight-for-age variance as expected.

- Increasing *sinkiro* size has a significantly negative effect on children's weight-for-age and weight-for-height. As the calorie consumption model showed, increased *sinkiro* size was associated with reduced calorie intakes per adult equivalent. Moreover, observations in large compounds (which tend to have the largest *sinkiros*) suggested that child care was particularly insufficient in these larger units. This implies that, while there may be positive scale effects in food consumption, there may be negative ones in producing child health and nutrition.

- Contrary to many Asian examples, boys here are found to be less well off than girls (height-for-age, weight-for-age). Yet there is a different bias; children of the compound head are significantly better off than others in the same family unit. Distribution of investment in children's health and nutrition is obviously not equal within compounds.

- Both weight-for-age and height-for-age are adversely affected in the long run if a child is born late in the dry season or early in the wet season. Children born in these periods are on average 8 percent more stunted (their estimated height-for-age Z-score is 8 percent less than the average).

- There are no indications that (degree of) access to the rice project has a negative or positive effect on nutrition beyond any of the factors already included in the model through which the indirect income-consumption effects show their positive effect on nutrition.

- The control variable that identifies the children without a written birth record suggests that mothers systematically tend to underestimate their children's age. A separate estimation of the same model for all the children with birth records did not significantly change the overall model results from those presented in Table 55. It is also noteworthy that mothers' height, which is partly genetically determined, has a highly significant effect for children's height and weight. The ethnic differences of height in the location are supposedly captured through this variable.

- Seasonality in weight loss is not fully explained by the consumption- and health-related variables in the model. Nutritional status in the wet season is estimated to be worse than in the dry season even after consumption and health variables are controlled for (DRYS).

In addition to the explanation of children's nutritional well-being, an attempt is made here to explain mothers' nutritional status in a model.

The dependent variable of this model is the weight-for-height (MWH; kilograms per centimeter) of mothers of the children in the sample. The considerable variance and seasonal fluctuation of women's weight, which is reflected in this variable, was described earlier. These differences and fluctuations are hypothesized to be determined

by women's food consumption levels (CAL) and by energy expenditure, as indicated by work load (WORKL). Only a rough indication is possible given survey data that cover women's activities for only one week in each of the two seasons. Above that, current health (SICK), pregnancy status (PREG), and individual status characteristics (compound head's wife, CHHUSB) are controlled for. The model is as follows:

$$\begin{aligned} MWH_{i,s,r} = f(CAL_{s,r}, CALSQ_{s,r}, WORKL_{i,s,r}, SICK_{i,s,r}, \\ PREG_{i,s,r}, NOCHL_{i,s,r}, CHHUSB_{i,s}, DRYs_r), \end{aligned} \quad (18)$$

where

NOCHL = number of children born,
CHHUSB = woman is wife of household head,
DRYS = dummy variable for dry season is 1,
i = woman,
s = *sinkiro*, and
r = survey round.

(For specific definitions of all variables, see Table 56.)

The results of the multivariate analysis show that household food energy consumption has a positive effect on mothers' nutrition, but the food consumption effect decreases at the margin.

Table 56—Determinants of mother's nutritional status: regression model

Variable ^a	Parameter	t-Value
CAL	3.735987E-03	3.524
CALSQ	-2.79431E-09	-1.564
WORKL	-8.47798E-04	-1.151
SICK	-6.21542E-03	-1.691
PREG	0.04032	4.496
NOCHL	3.735987E-03	3.524
CHHUSB	8.377180E-03	2.373
DRYS	0.01059	3.002
Constant	0.30493	16.824
R ²	0.080	
F-value	7.80	
Degrees of freedom	716	

^a Definitions of variables:

CAL = calories per adult-equivalent person per day from all sources, including snacks;
CALSQ = calories per adult-equivalent person per day from all sources squared;
WORKL = time spent working away from compound in day equivalents over one-week period;
SICK = if woman was sick during preceding four weeks (= 1, else = 0);
PREG = if woman is pregnant (seven months or more) (= 1, else = 0);
NOCHL = number of children born;
CHHUSB = woman is wife of a compound head (= 1, else = 0); and
DRYS = dummy variable for dry season (= 1).

The nutritional status of women who are wives of compound heads is significantly better than others. This indicates an unequal distribution of nutrition and health benefits among a compound's women, which was also found to be true for children. The seasonal effect on women's nutritional status is confirmed; women are significantly better off in the dry season.

To sum up, major findings of the nutritional effects of technological change in rice production include the following:

- The project raised household income, and thus calorie consumption, which in turn substantially improved the nutritional status of children. The shift in income control away from women has, however, somewhat limited the beneficial consumption effect.

- Mothers' weight loss in the wet season, which is not only a health and nutrition problem for the individuals but also indirectly for their children as it relates to low birth weight, was found to be reduced with increased access to the new rice land.

- The greater their access to the rice project, the more frequently mothers take their smallest children with them to the rice fields in the wet season. Since proximity to the swamps is associated with more sickness in children (that is, fever), there is a health problem that requires attention;³² the solution probably lies in appropriate supplementary program components for child-care support in the villages.

³² The percentage of children under five years of age found sick during the preceding four weeks of the recall period was 6.1 percent higher in the lowland villages than in the uplands, and the duration of sickness was on average 7.6 days in the villages close to the river compared with 4.8 days in the upland villages.

CONCLUSIONS FOR PROGRAMS AND POLICY

From this West African case study, generalizable conclusions are sought as guidelines for programs and policies designed to improve household-level food security and nutrition through technological change in agriculture and enhanced market integration. The attempt to generalize is made by confronting specific study findings with broader policy objectives and constraints. No attempt is made to outline a set of general prescriptions.

With the current situation of difficult economic adjustment in many African countries, programs need to be rigorously designed toward saving or generating foreign exchange, not creating a fiscal burden. Furthermore, in view of rising urban unemployment, there needs to be a focus on expanding rural labor demand and increasing productivity in agriculture (Mellor, Delgado, and Blackie 1987). These criteria may not necessarily be compatible with a narrowly defined focus on food self-sufficiency at the national level. For example, major irrigated rice schemes may use up resources that would make more rice—or other cereals—available if they were directed to other uses: minor irrigation, rainfed rice, other food crops, or exportable crops earning foreign exchange used to import food.

Agricultural growth fostered by technological change is documented in this study as a powerful force able to contribute toward the fulfillment of the above objectives and ultimately to the alleviation of poverty. While a strong positive relationship was established in this research between increased income, rising food consumption (from deficit levels), and nutritional improvement, there is ample scope for agricultural program design to maximize these welfare effects of agricultural growth by appropriate policy coordination in the fields of agriculture, infrastructure, and health.

Research on the rice project considered here has clearly shown that a narrowly focused promotion of output in one crop, through subsidized irrigation, did achieve increased production. However, this was achieved at high costs of investment and high opportunity costs of labor. The latter resulted from considerable output forgone from competing crops (other cereals and groundnuts) because labor, having high marginal productivity, was withdrawn from them.

Furthermore, it is shown that an understanding of the wider context of nutrition-deficiency problems and their causes is required in order to effectively mobilize program components for improvement of food security. The results stress that this should include paying more attention to seasonality in income and food availability, to women's work load, to the health situation, and to sanitation (water quality).

This is not to argue that individual projects should singlehandedly attempt to be "do-everything projects." Quite the contrary, given the past failures of many broad-based rural development programs in Africa. The research results stress, however, the importance of comprehensive policy coordination for rural poverty alleviation. To achieve effective nutritional improvement as a result of agricultural development programs, a complement in the form of health- and nutrition-related policies that combine long-term development concerns with a targeted short-term impact on nutrition is required. In countries dependent on farming, such as The Gambia, successful agricultural programs and policies have to provide the resources to fund such complementary measures and to make them sustainable in the rural sector.

Choice of Program Focus in Agriculture

Several factors may speak for a focus on rice in agricultural development programs in this West African setting: the irrigation-seed-fertilizer technology to promote rice is well known; rice is the main marketed cereal in rural and urban Gambia; in a country that imports 35 percent of cereals consumed, the import-substitution effect is favorable for the foreign exchange situation insofar as the chosen technologies permit incremental production at low foreign exchange cost; rice is particularly important as an income source for poor farmers in this area; and the rural poor get more calories from rice than do the upper-income groups.

However, the analysis of labor productivity by crop suggests that considerable scope exists for a multicrop focus rather than a single-crop focus. The analysis of the productivity of upland crops underlines the potentials of a policy that would move the agricultural production frontiers more broadly with functioning input delivery systems; that is, a fertilizer cum labor-saving implement program coupled with an effective rural credit scheme (explicitly open to women farmers or with a specific women's branch). Program planners need to be aware that the promotion of crops that compete with rice for labor and other resources (millet, maize, groundnuts) through broad-based policies for improved input delivery systems will further increase the opportunity cost of rice production. This calls for more attention to competition between crops for scarce labor resources and a less-narrow focus on physical output growth in a single crop.

The main commercialization effect of the new rice crop is driven on the input side by loan repayment requirements for fertilizer, seed, water charges, and land preparation services. The second effect is an expanding market for hired labor. The third is the marketed surplus from the new crop, which, however, was found to be rather low. While marketed surplus was found to be output- and price-elastic as expected, local infrastructure (that is, proximity to the road/markets) had a favorable effect over and above these elasticities. This stresses the potential role to be played by infrastructure in improving agriculture's integration into the exchange economy.

Choice of Technology for Rice

Since scarce water resources in the dry season limit the development of fully water-controlled rice, it is argued that more emphasis on the partly water-controlled rice technology for the wet season would be appropriate. Even if this type of rice does not have the positive smoothing-out effect on seasonal cereal supplies that is provided by a dry-season crop, it is still a more secure means of producing cereals than the purely rainfed upland farming. Women are more involved in this partly water-controlled technology, which appears second-best in terms of returns to labor from a farmer's perspective. Currently, this is largely because of the differential subsidies embodied in irrigation infrastructure allocated to the two rice technologies. The cost of production in this technology, however, has to come down substantially to be viable. Land-development cost in larger perimeters makes tidal and improved rainfed rice currently even more expensive than fully water-controlled rice in the Jahally-Pacharr project and not competitive with the import alternative. Smaller perimeters with less land-leveling cost per unit of area could probably sharply reduce costs.

The choice-of-technology issue in rice is, however, not simply a question of choice between technologies X and Y. In each type of technology there is a substantial proportion of farmers who produce rice competitively (compared with equivalent import prices) and others who do not. Mean values can provide only a rough guide. A key issue is to identify, through efficient monitoring, the technical constraints that keep certain

farmers at the upper end of the distribution of unit cost of production, and thereby find ways to move these costs downward. Again, this means rejecting the narrow approach of focusing on yield levels per unit of land instead of focusing on returns per unit of labor.

Under erratic, unfavorable rainfed conditions, owners of small, irrigated rice plots with substantial upland crop enterprises are caught up in a difficult decisionmaking process for farm production because of increased competition for their scarce labor resources. With labor productivity-increasing measures in upland crops, this competition is likely to be further intensified in a situation of land abundance, as noted above. The climatic difficulties of wet weather in July-August and cold weather in November-January require, for profitable double-cropping of irrigated rice, a high degree of timeliness in the management functions of farmers and schemes for accurate sequencing of the cropping program, and organization and mobilization of production support services and inputs. The difficulties in these management functions are compounded by complex crop-mix patterns. Although these accentuating forces impinge directly on the wet-season irrigated crop more than on the dry-season crop, their effects are transmitted through the crop-sequencing process into the dry-season crop.

Protection and Enhancement of Women's Productive Role in Agriculture

The Jahally-Pacharr project has a strong focus on protecting and enhancing women's role in crop production. Despite considerable efforts by program planners to maintain women's access to the new rice technologies, women farmers ended up mainly with access to the lower-level, lower-yielding technologies. The men, on the other hand, took control of the highest-yielding rice technology, which consequently increased their returns to labor much more than was possible for the women. The increased food security now provided by the new technology did not exist before in this location. Growing the new rice crop required a shift of male labor resources under the authority of compound heads from traditional *maruo* production in upland fields to the new rice fields. It was thus perhaps inevitable that the rice ended up under the control of compound heads. In view of this experience, how can women's participation in technological change be improved? Briefly, the lessons are these:

1. The selection of a "women's crop" for promotion does not guarantee that the new form of crop production will benefit women more than men.

2. Project managers cannot guarantee the protection of traditional production arrangements while at the same time fundamentally changing the nature of that production.

3. Women are much more involved in independent cash crop production (cotton, groundnuts) than has generally been acknowledged. Yet their access to means of increasing their labor productivity (fertilizer, tools) in these crops was less than men's. This finding indicates that there is a potential for women to be included in the mainstream of the agricultural development process through a program of upland cash crop promotion as well as the improvement of swamp rice, taking account of women's labor constraints.

Women's interest in the new rice technologies and in upland crops would be safeguarded and enhanced by increased access of women to credit for the short-term financing of productive inputs. It is not just fertilizer and seed acquisition that is required, but transport, on-field threshing machines, village-based milling machines, bridging of short-term labor bottlenecks by labor hiring, and so on. Village-specific women's groups that exist traditionally in many of the communities could form the basis for cooperative organs through which loan security might be provided.

The suggested move away from promoting a single crop (rice) to promoting improved labor productivity in rice and in upland crops together would further reduce the pressure for competition between men and women in rice production and thus permit women to capture a larger share of the benefits accruing from technological change.

Allocation Policies for Irrigated Land: A Food-Security Perspective

Complex land tenure issues arise when highly valued irrigated land is developed in an area where there is abundant (low-value) land supply for rainfed agriculture. Who should get access to the new land, to what extent, for how long, and under what conditions? An auction approach to land distribution cannot be recommended on equity grounds because the poor do not have effective access to capital markets. Any rationing criteria have to be complex. Original rights to land taken over by the scheme and household labor resources are key factors.

The distribution of new land among large numbers of villages and among many compounds within each village had a favorable effect in the Jahally-Pacharr case. The benefits of the dry-season crop for reduced calorie deficiency during the wet (hungry) season were well spread out among the local communities. There are no indications that potential returns to scale were lost by this approach. Traditional acquaintance with irrigated agriculture is not necessarily a recommended criterion for land distribution, since farmers from villages that had little experience in rice production obtained the highest yields in this project by carefully following production recommendations.

The development of small-scale irrigation schemes that provide farmers with a less drought-affected, additional income source in the form of food has obvious advantages for food security. Against the background of the very low savings rates of the rural poor, this food-security effect is particularly relevant in this West African environment where rural capital markets are thin.

With large year-to-year fluctuations in rainfall, labor productivity in rainfed agriculture fluctuates similarly, and this instability is transmitted to irrigated rice schemes through the labor supply to such schemes. Years of good rainfall are, therefore, bad for yields in irrigated rice, as labor is not forthcoming so much as in years of drought. This is reflected by the drop in yields in fully water-controlled rice from 6.6 to 5.2 tons from the drought year 1984 to the year 1985, which had reasonably good rainfall. The fixed cost per unit of output in irrigated rice is thus higher in years of good rainfall. Yet, as long as crop price levels and ratios are not much distorted, the resulting yield fluctuations due to the shifting of labor between crops are a consequence of efficient reallocation of resources.

A focus on stable yields in schemes under those circumstances would be misleading. Schemes have to live and cope with the phenomenon of fluctuations in this region. With a wider distribution of land in a scheme—that is, smaller plots per household—the transmitted fluctuation “problem” increases, as the income from irrigated rice becomes more marginal for each household. Yet the food-security benefit at the household level is certainly increased with a wider distribution. This food-insurance function of irrigated rice at locations where other means for improved household-level food security are scarce argues for broad access of villages and for small allocations of irrigated land per household. Choice of varieties (that is, fast-maturing ones) may ease the fluctuation problem to some extent.

Income of the Poor and Consumption Linkages

This study has stressed that the substantial differences in per capita income between households in rural Gambia are long-standing. A targeting of productive resources and employment toward the poor is thus called for in programs aimed at nutritional improvement through economic development.

Additional income generated by the poorer households translated into more food-energy consumption and more nutritional improvement than in the rest of the population. Calorie deficiency is largely confined to the lowest 25 percent on the income scale. These 25 percent are forced to adjust their calorie consumption downward in the hungry season, while the rest of the population does not. In principle, this suggests that emergency food aid programs could be targeted at much smaller groups in the rural areas than is frequently assumed in The Gambia. Administrative targeting, however, is not easy in this environment. It requires considerable knowledge about the specific communities. Local administrative capacities are too limited for such tasks.

Low income in this land-abundant setting is caused mainly by low labor productivity in agriculture, which in turn is a result of inability to acquire productivity-enhancing inputs and tools. Any additional income, derived from traditional cash crops (such as cotton and groundnuts), staple foods, or nonagricultural income and transfers (remittances), is expended equally on food and nonfood consumption, regardless of the income source. Whether the income is in the form of cash or food does not make any difference to changes in the food-energy consumption of households. This suggests that agriculture-based programs for poverty alleviation and nutritional improvement in this area do not need to be limited to food-crop promotion, but need to focus on the most effective way of promoting income growth among the poor, which may well be through technological change in food production.

Reinforcing Effects of Development on Nutritional Improvement

Increased income translating into food consumption was found to be a powerful force for the nutritional improvement of malnourished children in The Gambia. However, the complex web of nutrition and health interactions suggests that the improvement of health should be a direct target linked with raising consumption levels through income. Rural health services need to be upgraded and moved closer to areas of demand/need in order to enhance the favorable income-consumption linkages for nutritional improvement. A practical aspect of this is unclean village water supplies (found to be a significant factor in nutritional deterioration), which should be a priority focus of complementary programs of rural development. The burden on mothers' time for child care in the wet season, increasingly strained by extra work in rice, requires a creative, village-based response. Child-specific interventions, parallel with agricultural development, should focus on children of low birth weight and the factors causing a nutritional deterioration of children aged one to three years. This is where the key problem of child malnutrition lies.

As confirmed in this study, agricultural programs and policy can directly affect the symptoms and patterns of malnutrition. The positive effects of agricultural development can, however, be strengthened by effective public health services. These services should be coordinated in a strong national system that is designed to tackle, as a priority, the preventative and curative needs of the rural poor. A project-by-project approach to health delivery can easily lead to inefficiency and injustice.

APPENDIX:

SAMPLE SELECTION AND SURVEY DESIGN

Sample Selection

In the project area itself, eight villages were identified in a two-stage random sample selection. The Jahally-Pacharr Project Management Unit provided a complete list of project villages with information about village size and the project rice land allocated to each village. Eight villages were chosen from this list by stratified random sample. Stratification criteria were (1) size of the village (that is, number of households), (2) distance from the Jahally and Pacharr swamps, and (3) ethnic group. The profile of the selected villages (Table 57) shows the representation of both large and small villages around the two project sites (Jahally and Pacharr swamps), of ethnic groups, and of different degrees of involvement in the project.

Two additional villages located outside of the project area were chosen randomly from other rice-growing villages to broaden the variability of observations and to represent the situation in the Jahally-Pacharr area before the project started. Both villages are involved in traditional swamp rice production or older pump-irrigated rice schemes or both. Choosing only two villages outside the project area was considered sufficient, as village and household participation within the project area already showed great variability.³³

In the second stage of sample selection, a baseline survey of all households in the selected villages was carried out to provide basic information about household demography and project involvement. Roughly three out of four households in each village were chosen randomly from this survey for interviewing. As described in detail in Chapter 3, the "households" in the study area can be very large units (compounds), frequently with 40-80 people. Averages at village level range between 7.9 and 16.5 persons in the sample villages (Table 57). The random draw of households at village level mentioned above refers to compounds. A total of 168 compounds was drawn into the sample. However, in some of the Wolof, Mandinka, and Serahuli compounds, most of which are very large, the compounds were subdivided into subunits of decisionmaking and management of consumption and production affairs. In special interview sessions with female and male compound leaders, the compound structures were evaluated and, where appropriate, compound subdivisions were taken into account. In these cases when compounds were subdivided, all units were maintained in the survey to permit flexible aggregations if required for specific analytical questions. The subdivision of the compounds resulted in a total of 214 household units (in the case of Mandinka villages, usually referred to as *sinkiras*).

The study sample compounds from the eight villages in the project represent about 10 percent of the total compounds participating in the project and also about 10 percent of those compounds involved in the fully water-controlled rice production. Fifty-two percent of the sample compounds have an average field size of pump-irrigated rice exceeding 0.25 hectare (equivalent to one-half of a plot). The equivalent percentage

³³ Certainly, a larger and more regionally distributed sample is desirable. Logistical constraints prohibited that in the 1985/86 survey, but in a follow-up survey in 1987/88 the sample was extended to three villages on the north bank of the Gambia River.

Table 57—Profile of sample villages and sample compounds, 1985/86

Village	Number of Compounds in Village	Number of Compounds Selected for Survey	Main Ethnic Group	Distance from Project Land (kilometers)	Average Size of Sample Compounds (persons)	Area of Fully Water-Controlled Project Land		Coefficient of Variation
						Per Compound	(hectares)	
Njoben	50	28	Wolof	11	15.3	0.16	0.16	0.70
Pacharr	59	33	Mandinka	4	16.5	0.40	0.40	0.78
Dasilameh	50	36	Mandinka	4	9.3	0.63	0.63	0.55
Sinchou Abdou	15	11	Fula	4	8.8	0.22	0.22	0.86
Kussalang	18	13	Fula	11	7.9	...	...	...
Sare Samba Sumali	16	10	Fula	8	9.5	0.16	0.16	0.96
Sare Bala	7	7	Fula	6	8.4	0.14	0.14	0.11
Sukurr	10	8	Serahuli	3	16.1	0.56	0.56	0.32
Teteng Fara	12	1-1	Mandinka	...	9.8	...	...	...
Touba N'ding	12	11	Mandinka	...	8.1	...	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

figure for households in the total project area is 45 percent. The average field size (rice) of the sample farmer is slightly lower (0.56 hectare) than in the whole population (0.69 hectare). Some of the sample villages (those in the Pacharr swamp area) also have access to a considerable amount of partly water-controlled (tidal-irrigated) land in the project.

Averages of key indicators show that the selected sample comes close to being representative of the study area as a whole (Table 58).

Sample Design and Data Collection

The household survey was executed during the rainy season of 1985 (August-October) and during the dry season of 1986 (January-March). The data collection was carried out by a carefully trained enumerator team, closely supervised by IFPRI staff on a daily basis. IFPRI staff and enumerators lived in the villages throughout the surveys. Half of the enumerator team were women, who generally interviewed women.

Data collection was tailored to examine the complex production and food consumption situations in the households. Considerable time was invested in designing and pretesting questionnaires on production, consumption, and nutrition that were appropriate to the local conditions and the specific research task. The questionnaires were precoded for direct data entry after completion. The set of questionnaires for each survey round consisted of the following:

1. A *demographic questionnaire*, which identified persons belonging to the household and its demographic characteristics (family relationships, household organization) and those responsible for crop production or owning livestock or both. This questionnaire formed the basis for all other questionnaires by identifying the appropriate respondents for specific issues, such as head cooks of consumption units (for consumption survey), all mothers with children under 10 years of age (for nutrition and health survey), all adults (for expenditure and nonagricultural income survey), all farmers (for agricultural production and marketing survey), and compound heads (for storage survey).

Table 58—Project land farmed, by compounds and area

Compounds/Area	Total Project Area	Sample Compounds in Project Area with Access to Project Land
Number of compounds	1,414	152
Fully water-controlled area		
in project (hectares)	548.00	54.50
Area per compound (hectares)	0.39	0.36
Villages with high involvement in project ^a		
Number of compounds ^b	642 (45)	79 (52)
Area per compound (hectares)	0.69	0.56
Villages with low involvement in project ^a		
Number of compounds ^b	772 (55)	72 (48)
Area per compound (hectares)	0.13	0.14

Sources: Jahally-Pacharr records and 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

^a High = more than 0.25 hectare per compound of fully water-controlled land; low = less than 0.25 hectare per compound of fully water-controlled land.

^b Numbers in parentheses are percentages.

Because of the complexity of intrahousehold organization, much of the information was gathered on an individual-by-individual basis and later aggregated to the appropriate unit of observation (for example, individual snack foods of members of a cooking unit).

2. The *food consumption questionnaire*, which covered day-by-day, weekly, once-a-season, and more long-term recalls of food acquisition and consumption, plus eating and cooking arrangements.

3. The *health and nutrition questionnaire*, which was applied to all mothers or caretakers of children under 10 and included specific demographic, child-care, and child-feeding information on a child-by-child basis; morbidity recalls for children and mothers/caretakers; mortality information; mothers' time allocation (when working away from compound); and anthropometric measurements of children and mothers recorded in each round (weight and height).

4. The *expenditure and nonagricultural income questionnaire*, which applied to all relevant adults and included a week's snack food survey; a week's survey of frequent nonfood purchases; a long-term (seasonal) survey on large expenditures, using a list of 60 expenditure items or groups of expenses; nonfarm income in cash and in kind; and remittances.

5. The *agricultural questionnaire*, which applied to all men and women farmers and examined field-by-field data on inputs, production, use of crops for the relevant seasons, livestock, and vegetables. Institutional arrangements of production (communal, individual) were assessed. Labor inputs were enumerated on a field-by-field and operation basis by sex. Land use was measured in a subsample of 10 percent of fields to cross-check with recall information. Ethnic group-specific and compound-specific units of volume measures were used for quantities of output produced and marketed or otherwise disposed of. Prices for all major transactions of outputs and inputs during the recall periods were similarly measured in the units most convenient to households.

6. The *storage questionnaire*, which was carried out with the household head and other relevant adults, involved quantifying current stock levels by crop and by storage responsibility (individual and communal storage).

The complex surveys required considerable time and effort by the enumerator staff. A key to successful completion was the excellent rapport developed in the villages by the survey supervisors. For example, some of the senior staff were allocated fields by village headmen, and they organized their own upland field crop production during the survey. Few households dropped out of the survey.

In-Depth Study

Because of the diversity of household organization in this setting, an in-depth study (Webb 1989) on decisionmaking and resource control inside the household unit was added to the structured main survey. This more detailed analysis focused on a 10 percent subsample of the large sample households. The in-depth study provided micro-level data necessary for an assessment of the distributional effects of technological change and commercialization within the complex social networks that make up the Gambian household. Through closely supervised questionnaire surveys, participant observation, and a detailed accounting of labor flows, an attempt was made to identify the individuals most affected by the introduction of new agricultural technology.³⁴ This intrahousehold information was fed into the large-scale survey, permitting insights to be followed up in the field.

³⁴ For a fuller account of this in-depth survey's design, implementation, and results, refer to Webb (1989).

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